SOIL SURVEY

Lewis County Washington

Series 1941, No. 10

Issued December 1954

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATIONS
and the
STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soil for a long time know about the soil differences on their farms, perhaps also on the farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or on other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or farm enterprises. They do not know whether higher yields obtained by farmers in other parts of their county and State are from soils like theirs or from soils so different that they could not hope to get yields as high, even if they followed the same practices. One way for farmers to avoid some of the risk and uncertainty involved in trying new production methods and new varieties of plants is to learn what kinds of soils they have so that they can compare them with the soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

To find what soils are on any farm or other land, it is necessary first to locate this land on the soil map that accompanies this report. This is easily done by finding the township in which the farm is located and by using landmarks such as roads, streams, villages, dwellings, and other features to locate the boundaries.

Each kind of soil mapped within the farm or tract is marked on the map with a symbol. For example, all the areas marked Ce are Chehalis silty clay loam. The color in which the soil area is shown on the map will be the same as the color indicated in the legend for the particular type of soil. If you want information on the Chehalis soil, turn to the section in this publication on Soil Types and Phases and find Chehalis silty clay loam. Under this heading you will find a statement of what the characteristics of this soil are, what the soil is mainly used for, and some of the uses to which it is suited.

Suppose, for instance, you wish to know how productive Chehalis silty clay loam is. You will find it listed in the left-hand column of table 4. Opposite the name you can read the yields for different crops grown on the soil. This table also gives estimated yields for all the other soils mapped in the county.

If, in addition, you wish to know what uses and management practices are recommended for Chehalis silty clay loam, read what is said about this soil in the section on Soil Types and Phases. Refer also to the section headed Use and Management, where the soils suited to the same use and management practices are grouped together.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the section on Soil Series and Their Relations, which tells about the principal kinds of soils, where they are found, and how they are related to one another. After reading this section study the soil map and notice how the different kinds of soils tend to be arranged in different parts of the county. These patterns are likely to be associated with well-recognized differences in type of farming, land use, and land-use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate; the types and sizes of farms; the principal farm products and how they are marketed; the kind and conditions of farm tenure, including tenancy; availability of roads, railroads, electric services, and water supplies; the industries of the county; and cities, villages, and population characteristics. Information about all these will be found in the section on General Nature of the Area and in the section on Additional Facts About Lewis County.

Those interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication on the soil survey of Lewis County, Wash., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

the

WASHINGTON AGRICULTURAL EXPERIMENT STATIONS

and the

STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

Series 1941, No. 10 Issued December 1954

SOIL SURVEY OF LEWIS COUNTY, WASHINGTON

By R. H. FOWLER, in Charge, and A. O. NESS, Washington Agricultural Experiment Stations

Area inspected by RAY C. ROBERTS, Principal Soil Scientist, Division of Soil Survey,[1] Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture

United States Department of Agriculture in Cooperation with the Washington Agricultural Experiment Stations and the State Department of Conservation and Development

CONTENTS

[1] The Division of Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

NEARLY three-fourths of Lewis County consists of rough mountainous land suited primarily to forest; approximately one-fourth is land now farmed or suitable for farming. Considering that only about 25 percent of the land suitable for farming is actually so used, possibilities for increasing crop acreage are probably better in this county than in any other section of western Washington. Unfarmed areas most favorable for agriculture are the smooth uplands, terraces, and alluvial flood plains that have been logged over for the dense stands of coniferous timber they originally supported. The task of clearing this cut-over land of stumps and second growth would be difficult and costly but could be accomplished effectively by cooperative action. With a better knowledge of their soils, farmers could work out improved practices of soil and crop management that should bring higher yields and reduced production costs on both the areas now farmed and those that may be cleared in the future. To provide a basis for the best agricultural uses of the land, a cooperative soil survey of Lewis County was made by the United States Department of Agriculture, the Washington Agricultural Experiment Stations, and the Department of Conservation and Development for the State of Washington. Field work was completed in 1941. Unless otherwise stated, all information in the report refers to conditions in the county at that time. Results of this survey are the basis for this publication.

GENERAL NATURE OF THE AREA

Lewis County is in the southwestern part of the State of Washington (fig. 1). Rectangular in shape, it is about 95 miles long and 26 miles wide. It reaches westward from the crest of the Cascade Moun-

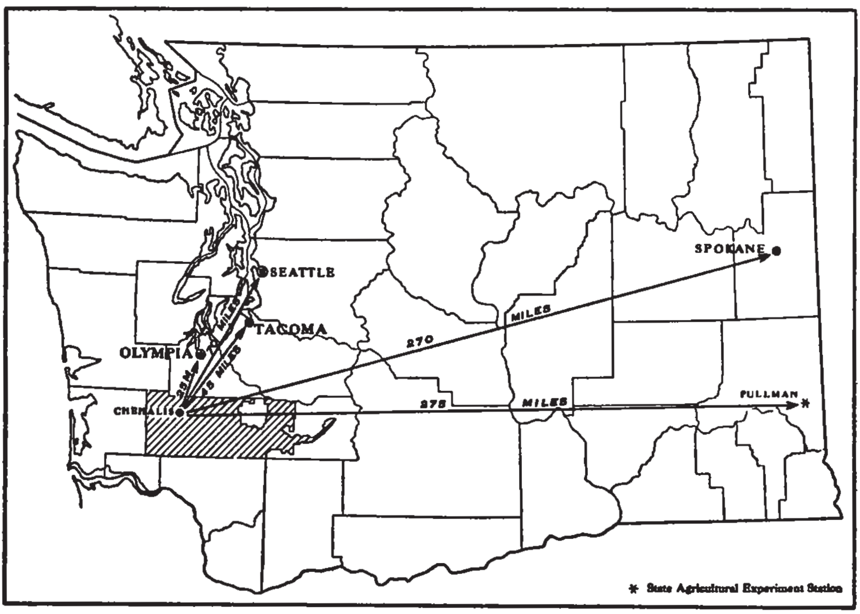


FIGURE 1.—Location of Lewis County in Washington, showing area surveyed.

tains to within 35 miles of the ocean. Chehalis, the county seat, is 70 miles southwest of Seattle, 25 miles south of Olympia, 270 miles southwest of Spokane, and 275 miles west of Pullman. About one-third of the county, principally the eastern part, is in the Snoqualmie and Gifford Pinchot National Forests and not included in this survey. The area surveyed covers approximately 1,543 square miles.

Like many other parts of western Washington, the county is to a large extent covered with forest. The few prairie areas were settled first. Clearing the forest and settling the rest of the land has been a slow process, especially in the uplands where the soils are of low fertility. In upland areas farms are small and generally owned by farmers who earn part of their living from lumbering and other industries. These part-time farmers usually have a small garden, some chickens, and a small dairy herd. The holdings are in various stages of being cleared. Only 1 or 2 acres of some farms are cleared; on others several acres are cleared and several acres are in stump pasture; on others 30 or 40 acres may be cleared and in crops, generally hay or grain. Buildings are also in various stages of completion.

Many of the prairie areas have been continuously cultivated, and yields from them now are much less than when the land was first cultivated. The best land in Lewis County is on recent alluvial areas adjacent to the large rivers; it is relatively productive of all crops commonly grown in western Washington. Dairying and poultry raising are also very important on these river flood plains. Farm buildings on these recent alluvial soils are more substantial and kept in better repair than those on the uplands.

The total population of the county in 1950 was 43,755 of which 29,459 were classified as rural and 14,296 as urban. The total population increased 9 percent in the period 1930–50.

Centralia, the largest town, had a population of 8,657 in 1950; Chehalis the county seat, 3 miles south of Centralia, had a population of 5,639. The inhabitants of these towns for the most part work in industries related to agriculture and lumbering. Pe Ell is the principal town on the branch line of the Northern Pacific Railway serving the extreme western part of the county. It had a population of 787 in 1950, and the principal sources of income are agriculture and lumbering. Winlock—about 12 miles south of Chehalis on the Northern Pacific Railway—had a population of 506. It serves an important egg-producing area. Toledo, in the southern part of the county, had a population of 602; Morton, in the east-central part, a population of 1,140. Morton derives its chief income from lumbering but is also the center of the cinnabar mining district; it is served by a branch line of the Chicago, Milwaukee, St. Paul, and Pacific Railroad. Other smaller trading centers are Napavine, Vader, Salkum, Silver Creek, Riffe, Mossyrock, Randle, and Doty.

Most of the arable soils occur below an elevation of 1,000 feet on the benchland between the two mountain ranges and along the narrow flood plains and terraces of the principal rivers. Most of the arable land in the western and central part of the county is close to the main highways and transcontinental railroads. In the eastern part of the county distance to market outlets is in many places excessive, but recent highway improvements have considerably alleviated this difficulty.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Lewis County extends from the Coast Range of the Pacific Border province across the Puget Trough into the Northern Cascade Mountains. The main physiographic divisions of the area surveyed are (1) alluvial flood plains, (2) undulating to gently rolling uplands and terraces, (3) hilly uplands, and (4) rough mountainous land (fig. 2).

The relief is rough over much of Lewis County. The Cascade Mountains are in the eastern part, and outlying hills and mountains of the Coast Range in the western. Relief is more moderate in much of the west-central part, which lies just south of the Puget Sound Basin and between the two mountain ranges.

The higher peaks of the Willapa Hills, or Coast Range, have elevations reaching 3,000 feet; [1a] these hills are composed of sedimentary and basaltic rocks of Tertiary age. The Cascades are composed principally of Miocene volcanics; they include many formations, but dominantly those basic in composition. In this county the Cascades reach elevations up to 8,000 feet. Mount Rainier, just north of the county line, has an elevation of 14,408 feet; Mount Saint Helens, a few miles south of the county, an elevation of 9,671 feet; and Mount Adams, a few miles southeast of the county, an elevation of 12,307 feet. These are snow-covered volcanic cones in the Cascades.

The county is drained in greater part by three river systems—the Cowlitz, Nisqually, and Chehalis. The swift-flowing Cowlitz and Nisqually Rivers originate on Mount Rainier, and most of their summer flow comes from melting glaciers and snow. The Cowlitz River flows nearly the length of the county, from the extreme northeastern to the southwestern part. With its tributaries, principally the Cispus and Tilton Rivers, it drains most of the eastern, central, and southwestern parts of the county before flowing south to the Columbia River. The Nisqually River forms the boundary between Lewis and Pierce Counties for some distance before emptying into Puget Sound; it drains the northeastern part of the county. The Chehalis River and its tributaries head in the outlying hills and Coast Range, and after draining the northwestern part of the county, flow in a westerly direction into the Pacific Ocean.

The approximate elevations of some of the towns in the county are as follows: Pe Ell, 411 feet; Centralia, 182 feet; Chehalis, 212 feet; Silver Creek, near the center of the county, 678 feet; Mossyrock, a few miles east of Silver Creek, 667 feet; Morton, in the east-central part of the county, 956 feet; Packwood, in the extreme eastern part of the county, 1,054 feet; and Randle, about 25 miles southwest of Packwood, 912 feet.

CLIMATE

Lewis County has a climate slightly more continental than that of counties bordering the ocean or Puget Sound. Because it is further inland, it shares only in part the mild even climate of western Washington. Temperatures are more extreme and the growing season is warmer than where the winds blow directly off the ocean.

Precipitation is high, ranging from about 45 inches at Centralia to more than 90 inches in the higher mountains. The rains are rarely torrential. Only about 25 percent of the rain falls during the growing

[1a] Elevations taken from topographic maps of the U. S. Geological Survey.

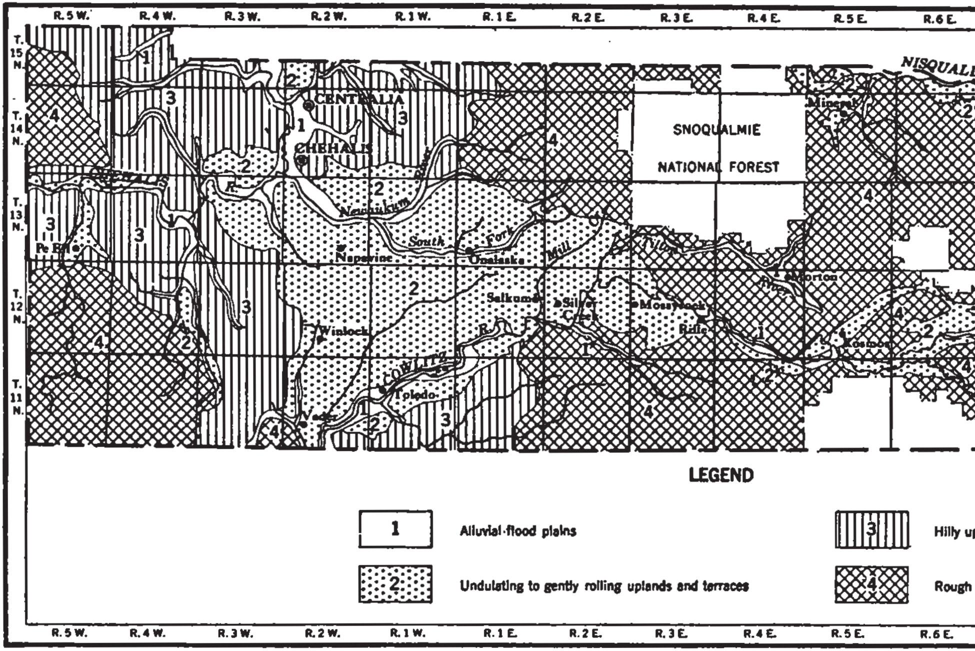


Figure 2.—Principal physiographic divisions of Lewis Cou

season (April 1 to September 31). Little effective rain falls from late in June to the middle of September. Occasionally summers are very dry, and when this occurs crops are severely damaged on the excessively drained and well-drained soils.

At lower elevations winter moisture falls chiefly in the form of rain, but in the higher mountains, largely as snow that accumulates to considerable depths. Occasional snowfalls at lower elevations remain only a short time, but in the foothills snow may stay for several weeks.

The barriers formed by the Coast and Cascade Ranges and the generally irregular relief cause marked variations in temperature and precipitation. Climatic data from any one location therefore are representative for only a limited area.

Normal monthly, seasonal, and annual temperature and precipitation considered most typical of the county are given in table 1, which was compiled from records kept by the United States Weather Bureau stations at Centralia and Kosmos. Centralia is in the west-central part of the county near the principal agricultural area; Kosmos, well to the eastern part of the county, in a small valley surrounded by mountains.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Centralia and Kosmos, Lewis County, Wash.*

CENTRALIA, ELEVATION 182 FEET

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	40. 6	63	−16	7. 56	2. 67	22. 12	2. 3
January	38. 6	66	3	5. 96	3. 93	8. 47	5. 1
February	41. 4	71	9	5. 01	3. 80	4. 14	3. 9
Winter	40. 2	71	−16	18. 53	10. 40	34. 73	11. 3
March	45. 4	82	14	4. 50	2. 99	6. 11	. 7
April	50. 2	94	23	3. 01	3. 53	. 83	. 1
May	55. 0	97	28	2. 37	1. 20	3. 36	0
Spring	50. 2	97	14	9. 88	7. 72	10. 30	. 8
June	59. 8	101	31	1. 94	. 76	1. 14	0
July	64. 4	102	33	. 61	(1)	. 10	0
August	64. 2	102	35	. 93	. 08	1. 54	0
Summer	62. 8	102	31	3. 48	. 84	2. 78	0
September	59. 2	94	24	2. 16	2. 46	3. 43	0
October	52. 8	87	22	3. 70	2. 73	4. 27	(1)
November	45. 1	75	5	7. 02	4. 67	3. 78	1. 3
Fall	52. 4	94	5	12. 88	9. 86	11. 48	1. 3
Year	51. 4	102	−16	44. 77	[2] 28. 82	[3] 59. 29	13. 4

[1] Trace. [2] In 1944. [3] In 1933.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Centralia and Kosmos, Lewis County, Wash.*—Con.

KOSMOS, ELEVATION 775 FEET

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	38. 6	62	−15	9. 29	3. 67	28. 45	4. 8
January	36. 6	68	−4	7. 88	5. 40	12. 07	17. 4
February	40. 0	72	8	5. 61	5. 77	4. 79	8. 5
Winter	38. 4	72	−15	22. 78	14. 84	45. 31	30. 7
March	44. 4	83	16	5. 67	4. 04	6. 69	3. 7
April	49. 2	89	21	4. 02	4. 05	2. 11	1. 7
May	54. 0	93	27	3. 03	3. 26	3. 53	0
Spring	49. 2	93	16	12. 72	11. 35	12. 33	5. 4
June	59. 4	95	29	2. 62	1. 79	3. 59	0
July	64. 6	104	32	. 98	0	. 16	0
August	63. 9	101	29	1. 54	. 27	2. 36	0
Summer	62. 6	104	29	5. 14	2. 06	6. 11	0
September	58. 6	97	26	2. 92	5. 72	5. 69	0
October	51. 4	91	20	4. 99	2. 02	8. 34	([1])
November	43. 8	74	7	8. 30	5. 07	5. 39	2. 3
Fall	51. 3	97	7	16. 21	12. 81	19. 42	2. 3
Year	50. 1	104	−15	56. 85	[2] 41. 06	[3] 83. 17	38. 4

[1] Trace. [2] In 1944. [3] In 1933.

There is a general lowering of the mean annual temperature and an increase in rainfall from the lower elevations in the western part of the county to the higher mountainous areas in the eastern. The growing season is longer in the western part, but is long enough in the eastern part for maturing of all crops. Frosts have been recorded at Centralia as late as June 20 and as early as September 8, but the average length of the frost-free season is 182 days, from April 24 to October 23. At Kosmos frosts have been recorded on June 20 and August 24, but the average frost-free season is 149 days, from May 9 to October 5. In the eastern valleys, rains in spring and summer are usually heavier and temperatures during summer average higher; consequently crops grow faster although the growing season is shorter. (For a more comprehensive discussion of the climate of western Washington see Reconnaissance Survey of Southwestern Washington (*8*).)[2]

[2] Italic numbers in parentheses refer to Literature Cited, p. 130.

WATER SUPPLY

Water supplies in the county are typical of those in western Washington. Perennial streams, creeks, and springs are principal sources of water for livestock. Most of the creeks, except those flowing through the excessively drained soils of the younger terraces, carry some water all year.

Domestic water comes from springs and pumps. Recently many pumps have been installed along the river bottoms for irrigating truck crops and dairy pastures.

VEGETATION

The native vegetation is largely a very heavy dense growth of conifers that reach huge size at maturity. On the steeper and higher slopes the trees may be smaller, but the stand is usually as dense as elsewhere. Most of the merchantable timber has been removed from the lower lying lands, but large areas of virgin timber still remain in the higher mountains. A few marshy areas are covered by deciduous trees and brush, and several small prairies support only grass and ferns or a few limby or stunted firs and oaks.

A particular kind of plant association usually indicates certain drainage conditions, but individual soil types rarely can be determined from the plant association alone.

Douglas-fir (*Pseudotsuga taxifolia*), the most important timber tree in the area, grows extensively throughout all parts of the area, often occurring in pure or nearly pure stands, particularly on soils having excessive underdrainage. Western hemlock (*Tsuga heterophylla*) is associated with the Douglas-fir in most areas. Western redcedar (*Thuja plicata*), also an important timber tree, requires adequate summer moisture and therefore thrives only where the soils have either an exceptional moisture-holding capacity or are kept moist by slope seepage or by a water table within 5 or 6 feet of the surface. Lodgepole pine (*Pinus contorta*) occurs in places on the excessively droughty soils and on the shallow poorly drained soils with a dense clay subsoil. Western white pine (*Pinus monticola*), Sitka spruce (*Picea sitchensis*), grand fir (*Abies grandis*), noble fir (*Abies nobilis*), and Alaska yellowcedar (*Chamaecyparis nootkatensis*) are found at higher elevations in the Cascades.

Deciduous trees are associated with the conifers but make abundant growth only where summer moisture is favorable. Ordinarily, the stand is good only on moist slopes or bottom lands where drainage is restricted. The most common deciduous trees are bigleaf (Oregon) maple (*Acer macrophyllum*), vine maple (*Acer circinatum*), and red alder (*Alnus oregonia*). These species and many kinds of brush and shrubs, including willow (*Salix* sp.), are the first invaders of logged-off lands, regardless of the kind of soil. Orgeon ash (*Fraxinus oregona*) grows on very wet soils; black cottonwood (*Populus trichocarpa*) occurs along stream courses. Quaking aspen (*Populus tremuloides*) occurs in places on the poorly drained soils that have a very dense clay subsoil. On dry prairies, both at the margins and in clumps upon them, Oregon white oak (*Quercus garryana*) is conspicuous. Among the more common shrubs are cascara (*Rhamnus purshiana*), Pacific dogwood (*Cornus nuttalli*), elderberry (*Sambucus cerulea* or *S. glauca*), and devilsclub (*Oplopanax horridum*).

The understory or ground cover is composed largely of Salal (*Gaultheria shallon*), Oregon grape (*Berberis aquifolium*), oceanspray (*Holodiscus discolor ariaefolius*), snowberry (*Symphoricarpos albus*), red (whortleberry) huckleberry (*Vaccinium parvifolium*), blackberry (*Rubus macropetalus*), salmonberry (*Rubus spectabilis*), and thimbleberry (*Rubus parviflorus*) as well as a variety of ferns and mosses. Bracken (*Pteridium aquilinum* var. *pubescens*) is the most common fern. It grows over a wide range of conditions and rapidly takes over after logging, burning, or clearing. The swordfern (*Polystichum* sp.) is common on moist ground in shady areas, especially in virgin timber. The cutting and shipping of this fern to eastern markets for decorative purposes has in recent years become a source of revenue for many people in the county.

In swampy areas and peat bogs are hardhack (spiraea) (*Spiraea douglasii*), wild rose (*Rosa nutkana*), and skunkcabbage (*Lysichitum americanum*), as well as more common shrubs and many water-tolerant grasses, sedges, and reeds.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of examining, classifying, and mapping of soils in the field. The soil scientist walks over the area at intervals not more than one-quarter mile apart and bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers, called horizons, which collectively are known as the soil profile. Each of these layers is studied carefully for the things about it that affect plant growth.

The color of each layer is noted. There is usually a relationship between the darkness of the upper layer of soil and its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration.

Texture—the content of sand, silt, and clay in each layer—is determined by the feel of the soil when rubbed between the fingers and is checked by mechanical analyses in the laboratory. Texture determines to a considerable extent the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and the difficulty or ease of cultivating the soil.

Soil structure, or granulation, and the number of pores or open spaces between soil particles determine the permeability or perviousness of the soil, and consequently, the ease with which plant roots penetrate the soil and water enters it.

Consistence, or the tendency of the soil to crumble or to stick together, determines the degree of difficulty that will be encountered in keeping the soil open and porous under cultivation. Consistence covers such soil characteristics as hardness, friability, plasticity, stickiness, compactness, toughness, and cementation.

Surface soil ordinarily refers to the surface layer, which is usually 5 to 10 inches thick. The layer just below the surface soil is the subsoil; the layer beneath the subsoil, the substratum.

The kind of rocks and parent soil material that develops from these rocks affect the quantity and kind of plant nutrients found in the soil.

Simple chemical tests are made to show the degree of acidity of the soil, and the depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features are observed.

On the basis of all the characteristics here listed, soil areas much alike in the kind, thickness, and arrangement of layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil type has slopes ranging from 2 to 30 percent, the type may be mapped in three phases, a gently undulating phase (2- to 5-percent slopes), a sloping phase (5- to 15-percent slopes), and a moderately steep phase (15- to 30-percent slopes). A soil that has been eroded in places may be mapped in two or more phases—an uneroded phase, an eroded phase, and perhaps a severely eroded phase. No eroded phases, however, are mapped in Lewis County. A soil type is broken into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of a soil, the frequency of outcropping bedrock found in it, the extent of its erosion, or the artificial drainage used on the soil, for example, are characteristics that might cause a soil type to be divided into phases.

Two or more soil types may have similar profiles; that is, the soil layers may be nearly the same, except that the texture, especially of the surface layer, may differ. As long as the other characteristics of the soil layers are similar, these soils are considered to belong in the same soil series. A soil series therefore consists of all types, whether the number be only one or several, that are, except for texture—particularly the texture of the surface layer—about the same in kind, thickness, and arrangement of layers.

The name of a place near where a soil series was first found is chosen as the name of the series: thus Winston is the name of a series of shallow, excessively drained, acid, coarse-textured soils found on sandy and gravelly stream-laid deposits in Lewis County. Four types of the Winston series are found—Winston loam, Winston gravelly loam, Winston gravelly sandy loam, and Winston silt loam. Each of these soil types has a different surface soil texture, as their names indicate. Winston gravelly sandy loam is divided into three phases. Areas of the soil having 2- to 5-percent slopes are designated as gently undulating; those having 5- to 15-percent slopes are designated as sloping; and those having 15- to 30-percent slopes are known as moderately steep.

When very small areas of two or more kinds of soil are so intricately mixed they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Meskill-Melbourne silty clay loams is a complex of Meskill silty clay loam and Melbourne silty clay loam in Lewis County.

Bare rocky mountainsides, riverwash, or rough broken land that have little true soil are known as miscellaneous land types and are not designated with series and type names but are given descriptive names, as Rough mountainous land (Olympic soil material), Riverwash, Rough broken land, and Made land.

The soil type or, where the soil type is subdivided, the soil phase, is the mapping unit in soil surveys. It is the unit or the kind of soil that is most nearly uniform and has the narrowest range of characteristics. For this reason land use and soil management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Chehalis series are well suited to general farm crops. More specifically it can be stated that Chehalis silty clay loam is well drained, warms up early in spring, and affords a long growing season; whereas, in contrast, Chehalis silty clay loam, mottled subsoil, is not so permeable, somewhat less well drained, and more difficult to manage during years of above-normal precipitation, but is better for most farm crops during dry years. In addition, it can be said that both of these silty clay loams are more difficult to till than Chehalis silt loam and Chehalis silt loam, mottled subsoil.

SOIL SERIES AND THEIR RELATIONS

The range in rainfall and temperature in this county is small, but the soils have developed under such a diversity of relief and drainage and upon such a wide variety of parent materials that they have been classified into a large number of different soil series. Many of the soils classified occur only in this and adjacent counties. In some districts, particularly in the mountainous valleys, the soils have exceedingly variable profiles and intricate patterns of distribution.

Age, parent materials, and heavy texture of the soils of this county bring them into striking contrast with the light-textured, gravelly, more youthful, and shallower soils of the Puget Sound Basin, which lies north of the county and extends to the Canadian border. Most soils of this county have developed over a long period of time and therefore have deeply weathered parent materials and heavy textures. In spite of this, the majority, even the cut-over soils, have excellent structures for penetration of water, air, and roots and in many areas have good depth, adequate drainage, and properties making them easy to till. Because they have developed under fairly high precipitation, they are strongly leached and slightly acid. Despite the severe leaching, no definite layer of illuviation is evident in soils of most of the series.

Their organic-matter content is moderately high, but fertility is low because supplies of available nitrogen and phosphorus are deficient. The soils need fairly large applications of fertilizer if they are to produce good yields of cultivated crops continuously.

The arable lands consist chiefly of undulating uplands and very old terraces in the west-central part of the county. Probably more than two-thirds of these lands are now covered with stumps and second-growth timber.

The most intensive farming is done on the fertile alluvial flood plains. The crops—generally grown for dairy cattle—are small grains, hay, and pasture. The soils of the flood plains are naturally fertile and produce high yields. Summer pasture, clover, and alfalfa on better drained land near an adequate water supply are benefited by irrigation. Some irrigation is often necessary to maintain

pasture throughout summer in drier years. The poorly drained soils are usually farmed with better drained ones, but they are more unreliable for such use and better for permanent pasture. The use of phosphate fertilizer and barnyard manure or some other source of nitrogen has proved beneficial.

The most extensive agricultural areas are on the undulating uplands and old terraces. Soils in these areas are heavy-textured but have a granular structure that makes them friable and easily worked. Winter wheat, winter oats, grass hay, and grain hay crops do well. Clover is difficult to get started, but once established does fairly well. Alfalfa has not been grown successfully. Pasture grasses usually dry out late in summer on the better drained soils but do fairly well on the poorly drained soils. Where small areas of poorly drained soils are farmed with better drained soils, the extra forage obtained from the poorly drained soils increases the desirability of the farm.

Under proper management yields on the uplands and old terraces are good but not so high as on the soils of the flood plains. Farm acreages and especially the area of cleared land are usually too low to provide an adequate income. Farms on the upland areas should contain at least 80 acres, not less than half of which should be cleared for cropping, and a good part of the rest should be available for grazing. The soils must have high organic-matter content if their fertility is to be maintained; however, those low in calcium are not always benefited by liming, and liming should only be done after soil testing.

The need for erosion control in western Washington, and particularly in Lewis County, is not great. Growth of plants is rapid and abundant on cut-over land, and the soils are able to take up water readily. Even under 40 and 60 inches of rainfall, erosion loss is relatively insignificant. Comparatively few of the soils are subject to accelerated erosion if simple precautionary measures are taken to prevent erosion.

With respect to topographic position the soils of Lewis County are placed in eight groups—six major groups and two additional groups composed of organic soils and miscellaneous land types, respectively. The groups are as follows: (1) Soils of uplands (from hard rock materials); (2) soils of uplands or old terraces (from mixed silty materials); (3) soils on mixed gravelly materials of old terraces or ancient glacial deposits; (4) soils of younger terraces; (5) soils of alluvial fans; (6) soils of alluvial flood plains; (7) organic soils (in depressions); and (8) miscellaneous land types. The miscellaneous land types are Riverwash, made land, four kinds of rough mountainous land, and two kinds of rough broken land. They are usually considered non-cultivatable because they have little or no soil. These eight groups, insofar as possible, are divided into subgroups on the basis of drainage—well drained, imperfectly drained, or poorly drained. The soils in each of the eight groups are shown in table 2.

TABLE 2.—*Physiographic group, parent material, and drainage of the soil series*

Group	Parent material	D
Soils of uplands (from hard rock materials).	Basic igneous material	Good
	Sandstone	do
	Shale and sandstone	Moderate Imperfect
Soils of uplands or old terraces (from mixed silty materials).	Mixed silty-textured (pumice) materials	Good Moderate
Soils on mixed gravelly materials of old terraces or ancient glacial deposits.		
Terraces	Weathered mixed gravelly materials	Imperfect
	Weathered mixed gravelly materials (forested).	Good
	Partly weathered mixed gravelly materials (forested).	do
	Weathered mixed gravelly materials (prairie).	do
	Partly weathered mixed gravelly materials (prairie).	do
Terrace depressions	Weathered mixed gravelly materials	Poor
Soils of younger terraces:		
Terraces	Gravelly glacial outwash (forested)	Excessive
	Gravelly glacial outwash (prairie)	do
	Gravelly stream-laid materials	do
	Sandy glacial outwash (forested)	do
	Sandy glacial outwash (prairie)	do
	Sandy stream-laid materials	Good
	Mixed silty material (forested)	do
	Mixed silty material (prairie)	do
	Mixed materials influenced by pumice	do
	Pumice	do

Terrace depressions	Mixed silty materials	Imperfec
	Gravelly materials	do
	Mixed materials influenced by pumice	do
	Sandy glacial outwash	Poor
	Mixed silty materials	do
	Pumice	do
Soils of alluvial fans	Basic igneous materials	Good
	Shale and sandstone	Imperfec
Soils of alluvial flood plains	Mixed basaltic material and glacial rock flour.	Excessive
		Good
		Imperfec
		Poor
	Mixed basaltic materials and glacial rock flour influenced by pumice.	Good
		Poor
	Mixed shale, sandstone, and basaltic material.	Good to
		Good
		Imperfec
		Poor
Organic soils (in depressions)	Alluvium over woody accumulation	Poor
	Organic decomposed woody accumulation	do
	Organic woody accumulation	do
Miscellaneous land types:		
Uplands	Mixed materials	Variable
	Variable	Good
Bottom lands	Very coarse textured alluvium	Excessive

SOILS OF UPLANDS (FROM HARD ROCK MATERIALS)

The soils of the uplands (from hard rock materials) are members of the Olympic, Vader, Melbourne, and Meskill series. They are derived from Tertiary sandstone, shale, and basalt rock formations, mostly of Eocene age but to some extent of Oligocene and also Miocene ages. Soils of the Olympic series are derived from basalt; those of the Melbourne and Meskill series, from argillaceous shale and sandstone; and those of the Vader series, mainly from softly compacted sandstone. All these soils, and especially those derived from sandstone and shale, are moderately acid and fairly low in inherent fertility. They occur principally in the rougher parts of the county on hilly land or slopes adjacent to the mountains.

The soil series can be distinguished by color, parent material, nature of subsoil, and drainage relations. Soils in the western part of the county have dominantly a silty clay loam surface soil on only moderately compact and slightly heavier subsoil. They are very friable and granular, easily tilled, and take water readily. Erosion loss is at a minimum. The soils are moderately acid, low in active organic matter, and relatively low in available plant nutrients because they have been weathered and leached over a long period. They are, however, responsive to good management and fertilization.

The soils of the uplands in the central and eastern parts of the county are predominantly silt loams. They are deeper than the upland soils in the western part and have a very mellow feel and good granular structure. They are generally more youthful and consequently higher in inherent fertility. Crops grown on them respond well to fertilization and good management.

OLYMPIC SERIES

Soils of the Olympic series range from reddish brown to brownish red and have developed from parent material weathered from basalt rock. They have a well-developed granular structure and are moderately acid. Their subsoil is firm to compact but permeable and well drained. Depth to bedrock ranges from 4 to 20 feet. The surface texture is heavy silty clay loam; the subsoil is slightly heavier but not strongly compacted.

VADER SERIES

The soil of the Vader series occupies a relatively small area and is derived from softly compacted sandstone. It has a lighter texture, more yellow surface soil and subsoil, and a less compact subsoil than the Melbourne soils. It is more subject to erosion than other soils in the county.

MELBOURNE SERIES

Member soils of the Melbourne series are granular, friable, and moderately well drained. They have brown to dark grayish-brown heavy-textured surface soil over a yellowish-brown slightly compact but permeable subsoil. This material grades into disintegrating clayey sandstone and shale at 2 to 4 feet.

MESKILL SERIES

Soils of the Meskill series are the imperfectly or poorly drained members of the upland soils group derived from hard rock material. They occupy sedge-covered seep slopes and depressions in association with the Melbourne soils. They have light-gray to light brownish-gray heavy surface soil that compacts easily. The subsoil and substratum are gray, mottled, dense, compact clays. Being wet and difficult to work, these soils are among the poorest in the county.

SOILS OF UPLANDS OR OLD TERRACES (FROM MIXED SILTY MATERIALS)

The soils on uplands or old terraces derived from mixed silty materials are members of the Wilkeson and Cinebar series. They occur partly on old high terraces and partly on uplands. The origin of their fine-textured silty parent material has not been definitely determined; probably it comes from wind-deposited, weathered, fine-grained pumice that has accumulated on terraces and upland hills. Soils of these two series are generally deep, silty, yellowish brown, acid, and fairly permeable. The Cinebar soils are more permeable than the Wilkeson and appear to be younger, less acid, and more productive. The Wilkeson soils occur farther east, at higher elevations, and under heavier precipitation than the Cinebar.

WILKESON SERIES

Soils of the Wilkeson series are moderately well drained and have a brown granular friable surface soil that grades into a slightly more compact yellowish-brown granular subsoil, which is heavier textured and slightly mottled in the lower part. The subsoil grades at varying depths into basaltic fragments, possibly influenced by Cascade glaciers. In places the substratum is partly cemented gray till that rests within a few feet upon the bedrock. Most Wilkeson soils occupy hilly and rough broken relief. Only a small area of these soils is smooth, and very little is farmed. More extensive smooth areas occur in Pierce County but only a small part is farmed there, probably because the soils lack available nitrogen, phosphorus, and other plant nutrients.

CINEBAR SERIES

Soils of the Cinebar series are similar to those of the Wilkeson series in physical characteristics but have a mellower and more friable surface soil and more permeable and lighter textured subsoil. They occupy undulating or gently rolling relief and occur at lower elevations than the Wilkeson soils. A large acreage is farmed, but a larger acreage is cut-over land. Some areas are still in virgin forest. The Cinebar soils are very responsive to good management and give good yields of grain and hay.

SOILS ON MIXED GRAVELLY MATERIALS OF OLD TERRACES OR ANCIENT GLACIAL DEPOSITS

The soils on mixed gravelly materials of old terraces or ancient deposits consist of four well-drained, one imperfectly drained, and three

poorly drained soil series. These are among the more mature agricultural soils in the county and occupy the most extensive areas either already farmed or available for clearing. As a group they are characterized by rolling relief and an entrenched drainage system. In general, they are developed from very old deposits, some of which are probably of glacial origin. Soils of the Salkum and Winlock series are probably the oldest, followed in order by the well-drained Onalaska and Doty soils, which closely approach the age of soils on the lower terraces and in some ways are difficult to distinguish from them. No claypan has developed in the well-drained areas. Leaching has been severe and fertility is low.

Soils of the Salkum and Onalaska series appear to be derived from similar parent materials, although the Onalaska are more youthful. Soils of the Winlock series are similar to the Salkum soils but have developed under a grass-and-fern prairie cover. The soil of the Doty series is similar to those of the Onalaska series but it also has developed under a grass-and-fern prairie cover. The Salkum soils are distinguished most easily by their substratum consisting of clay and strongly weathered and softened gravelstones. The Onalaska soils are distinguished from the Salkum soils most easily by the more youthful appearance of their substratum and by their lower terrace position.

WELL-DRAINED SOILS

First described are well-drained soils of this physiographic group—the Salkum, Onalaska, Winlock, and Doty.

SALKUM SERIES

Soils of the Salkum series have a brown or dark-brown silty clay loam surface soil, granular and friable and containing many shotlike particles. The subsoil is slightly heavier than the surface soil, slightly compact, and reddish brown when wet. At about 32 to 40 inches the subsoil grades into a highly colored clay-and-gravel matrix that is in places 50 to 100 feet or more deep. This parent material is so strongly weathered that the gravel is completely broken down and easily cut through with a spade. At extremes of wetness and dryness the profile differs very much in color. The soil is pale yellowish brown when dry, but when wet is dark reddish brown with many shades of red, orange, and purple, especially in the substratum.

ONALASKA SERIES

Soils of the Onalaska series, occurring principally on very old high terraces along the Cowlitz River, are more recent than other soils in this physiographic group. Their surface soil is dark brown, granular, friable, and contains some shot. The subsoil is firm but not so heavy or compact as the subsoil of the Salkum soils. At a depth of about 28 to 36 inches the subsoil rests on a much weathered gravelly substratum in which the gravel is only partly softened.

WINLOCK SERIES

Soils of the Winlock series are prairie counterparts of the Salkum soils. They have developed from the same parent material but under

a grass-and-fern cover. The surface soil is dark brown or dark grayish brown, granular, friable, and contains no shot.

DOTY SERIES

The soil of the Doty series is considered a prairie counterpart of the Onalaska soils, although in some instances it occupies a more youthful position. It differs from Onalaska soils principally in having a very dark-brown surface soil varying from 16 to 20 inches deep. Usually this soil is 36 to 48 inches deep to the gravelly substratum.

IMPERFECTLY AND POORLY DRAINED SOILS

The imperfectly and poorly drained soils of this physiographic group are the Scamman, Kopiah, Lacamas, and Tower. They occupy nearly level depressional areas where surface drainage is restricted. They occur principally in the general area of Salkum soils and probably developed largely from similar materials. Under conditions of restricted drainage they have developed a heavy, dense, gray clay subsoil. These soils are strongly weathered, moderately acid, and seriously leached of plant nutrients, but they respond well to good management and fertilization.

SCAMMAN SERIES

Soils of the Scamman series have light-brown or light yellowish-brown surface soil and dense gray clay subsoil, moderate surface drainage, and restricted internal drainage. They occupy positions midway between Salkum soils and Lacamas or Kopiah soils. The surface soil is brown or grayish brown, granular, and friable; it grades into a gray moderately compact clay subsoil very similar to that of the Lacamas soils.

KOPIAH SERIES

Soils of the Kopiah series usually occur along minor stream channels in association with Salkum soils. They are imperfectly to poorly drained. The surface soil—gray or brownish gray, slightly granular, and moderately friable—grades into a heavier, slightly compact, gray clay subsoil. At a depth of 3 or 4 feet the subsoil grades into highly weathered material similar to that underlying Salkum soils—a matrix of highly stained clay and softened gravel. The Kopiah subsoil is not so dense or compact as that of the Lacamas soils, and the surface soil is not so light a gray.

LACAMAS SERIES

Soils of the Lacamas series occupy relatively large depressional areas in the Salkum plain and are poorly drained. Their surface soil is light olive gray (very light gray on drying) silt loam or silty clay loam 12 to 18 inches deep. It is abruptly replaced by a very dense and compact waxy gray clay subsoil that extends to a depth of 3 feet or more. Drainage is more restricted and the subsoil is denser and deeper than in Kopiah soils.

TOWER SERIES

The soil of the Tower series occupies a few depressional areas in the Salkum plain. It is poorly drained but differs from the Scamman,

Lacamas, and Kopiah soils in having a dark or very dark brownish-gray surface soil and very dense subsoil. The surface soil. a dark-gray heavy clay, tends to form hard clods and develops wide deep cracks when dry. The subsoil is very dense, compact, heavy, greenish-gray clay with some rusty-brown mottlings. The subsoil grades into a lighter gray, mottled, dense clay substratum that may be underlain by gravel and cobblestones. Internal drainage is restricted.

SOILS OF YOUNGER TERRACES

A large number of series are represented on the younger terraces. The soils developed from a wide variety of parent materials under a wide range of conditions. They occur on nearly flat outwash plains at the most southern limit of continental glaciation in the Puget Sound region and are composed of material left by the Vashon glacier. Considered as a whole, the soils are extremely gravelly, porous, droughty, and relatively unproductive. Soils of some of the series occupy only a small area and are relatively unimportant.

The soils of the younger terraces are derived from old valley fillings, terrace deposits, and glacial outwash now above flood stage of the present streams. They are more maturely developed than the soils of the recent alluvial flood plain but still may be considered young or immature. Most of the soil series have a few shot in the surface and upper subsoil and are yellowish or brownish in color, the yellow being more pronounced in the subsoil. These terrace soils are less severely leached than the older soils and retain a higher inherent fertility. Drainage conditions vary from excessive to poor or swampy.

WELL-DRAINED AND EXCESSIVELY DRAINED SOILS

The well-drained and excessively drained soils of the younger terraces are members of the Olequa, Riffe, Winston, Grande Ronde, Mossyrock, Glenoma, Greenwater, Cispus, Fitch, Lynden, Nisqually, and Spanaway series. Some of these soil series are grouped to bring out relations more clearly; others are discussed separately.

OLEQUA, RIFFE, AND WINSTON SERIES

The Olequa, Riffe, and Winston constitute an important family of soils on the younger terraces. Soils of these series are derived from mixed sedimentary and basic igneous materials. They have a brown to slightly grayish-brown granular friable surface soil and a yellowish-brown permeable subsoil. A few shot are scattered throughout the surface soil and upper subsoil. The Olequa soils occupy positions usually above those of the Riffe and Winston and have a more strongly developed profile and firm subsoil. The Winston soils are distinguished by gravel in both the surface soil and subsoil and by a gravelly porous substratum. The Riffe soils are associated with the Winston soils but are free of gravel. The Riffe surface soil is brown loam or fine sandy loam, and the subsoil is yellowish-brown sandy loam or loamy sand. The Olequa soils have a medium-textured to heavy-textured subsoil, the Riffe a light-textured subsoil, and the Winston a course, gravelly-textured subsoil.

GRANDE RONDE SERIES

Soils of the Grande Ronde series are developed from materials derived to greater extent from sandstone and shale than from basalt. The material is principally from eroded Melbourne soils. Grande Ronde soils have brown heavy-textured granular surface soil and contain many shotlike particles. The subsoil is yellowish brown, firm, and granular; and the lower subsoil is gritty, high in content of weathered yellow sandstone fragments, and slightly stained.

MOSSYROCK SERIES

The soil of the Mossyrock series occurs in the eastern part of the county. It developed from parent material laid down by early postglacial stream action, which was eroded from Cinebar and Wilkeson soils or from similar sources. The Mossyrock soil developed under a grass rather than forest cover. It has a very dark brown or black deep mellow friable surface soil 16 to 20 inches deep and a mellow yellowish-brown silty subsoil similar to that of the Cinebar soils.

GLENOMA SERIES

Soils of the Glenoma series are limited to the Rainy Valley district near Kosmos in the eastern part of the county. The soil material is derived from terrace deposits along the Cowlitz River and has undergone subsequent reworking by local stream action. The most distinguishing characteristic of the soils is pockets or layers of pumice fragments in the profile. The surface soil is brown- or grayish-brown granular and friable loam or clay loam resting on a layer high in pumice. Below the pumicy layer, the subsoil is brown clay loam or clay free from pumice, firm but permeable, and mottled with yellow and rust brown below 3 feet. Surface drainage is good, and internal drainage only slightly restricted.

GREENWATER SERIES

Areas of Greenwater soils occur mainly on terraces along the upper Nisqually River, but some are along the Cowlitz River. The soils are derived from highly andesitic and basaltic coarse sands deposited by glacial or postglacial stream action. The surface soil is yellowish-brown or light brownish-gray loamy sand or sandy loam that is loose and friable. The subsoil is yellowish-brown coarse firm loamy sand, which is semiconsolidated in places but breaks to a single-grain structure. The lower subsoil and substratum are composed of coarse angular pepper-and-salt sands. Small yellowish-brown pumice fragments are scattered throughout the surface soil and subsoil. In most places these soils have excessive subdrainage.

CISPUS SERIES

Soils of the Cispus series occupy terrace positions above the valley floor and are confined to the general area between Kosmos and Randle in the eastern part of the county. They are composed entirely of pumice fragments varying from the size of a small pea to more than 2

inches in diameter. The soils are very loose, coarse, and porous. They range from 20 to 60 inches deep but average somewhere between 2½ and 4 feet and rest upon terrace material similar to that of the Glenoma soils. The pumice was erupted from Mount Saint Helens and blown to this area by southwest winds.

FITCH, LYNDEN, NISQUALLY, AND SPANAWAY SERIES

Soils of the Fitch, Lynden, Nisqually, and Spanaway series are derived from glacial outwash materials. They occupy only about 6 square miles in this county, but are extensively developed farther north. They occur on a gravelly outwash plain left by the last continental glaciation, which covered the Puget Sound area and extended into this county as far as Centralia. This plain has relatively level to undulating topography and consists mostly of exceedingly gravelly and sandy deposits. Soil-development processes have altered, at the most, only the upper foot or two of the material to any appreciable extent.

The four soil series can be divided into two distinct groups—soils developed under sparse timber or prairie, and soils developed under a forest cover. The Spanaway and Nisqually soils developed under prairie and have very dark grayish-brown surface soil. The Lynden soil is timbered and has a brown surface soil. The Fitch soil, also developed under forest, has a brown to dark-brown surface soil. The Spanaway and Fitch soils are extremely gravelly, whereas the Nisqually and Lynden soils are free from gravel. The Everson soil, elsewhere discussed, is a poorly drained hydromorphic associate of the Lynden soils.

The Fitch, Lynden, Nisqually, and Spanaway soil series are separately described in the following paragraphs.

The soil of the Spanaway series is more extensive than soils of the Nisqually, Fitch, and Lynden. It has a very dark grayish-brown sooty gravelly sandy loam surface soil, 12 to 18 inches deep, that grades within a few inches into a gray loose porous mixture of gravel and sand. This soil is very droughty and low in fertility.

The soil of the Nisqually series also has a very dark grayish-brown sooty loamy sand surface soil that grades, at a depth of about 18 inches, to lighter brown. At 32 to 36 inches occurs loose olive-gray coarse and fine sand. Nisqually soil differs from the Spanaway soil in being relatively free from gravel throughout the profile.

The Fitch soil has developed from very gravelly material similar to that of the Spanaway soil but under a sparse forest cover, which has given it a color intermediate between that of the prairie soils and the forested soils. Its surface soil—brown to dark brown, gravelly, and loose—grades through a brown loose subsoil into a gray loose gravel-and-sand substratum. The soil is excessively drained and droughty.

The Lynden soil has developed from outwash sand deposits under a forest vegetation and has a brown or light reddish brown surface soil over pepper-and-salt gray stratified sand subsoil and substrata. The Lynden soil is more productive for some truck crops than some of the heavier textured soils of the younger terraces.

IMPERFECTLY AND POORLY DRAINED SOILS

The imperfectly and poorly drained soils of the younger terraces belong to the Clackamas, Dryad, Klaber, Everson, Baugh, and Kosmos series. They are poorly drained or hydromorphic associates of the well-drained soils. Soils of the Clackamas series are associated with the Doty and Winston; those of the Dryad series with the Olequa and Kopiah; the Everson soil with the Lynden; the Baugh soil with soils of the Cispus series; and the Kosmos soil with soils of the Glenoma series.

CLACKAMAS SERIES

Soils of the Clackamas series are closely associated with the gravelly subsoil phases of the Klaber soils and are differentiated from them principally by their very dark grayish-brown surface soil and moderately compact mottled subsoil. They are usually heavier and less friable than the Klaber soils with gravelly subsoil, but are more fertile because they contain more organic matter. Depth to the underlying substratum of clay and gravel is variable but generally 2 to 3 feet.

KLABER SERIES

The Klaber soils occur in widely distributed nearly level relatively poorly drained areas on river terraces. They occupy lower more poorly drained positions than Dryad soils, have a more grayish surface soil, and show more compaction in the subsoil.

DRYAD SERIES

Soils of the Dryad series are imperfectly drained. In association with soils of the Olequa and Kopiah series they form a catena, or group, of soils differing in drainage. The Dryad surface soil is brownish gray, slightly granular, and friable; its subsoil is lighter gray, slightly compact, and faintly stained and mottled with rust brown and yellow. The subsoil is not so heavy or compact as that of soils in the Kopiah series.

EVERSON SERIES

The soil of the Everson series occupies only a little more than 100 acres and is confined to a few small depressional areas associated with the Lynden soil. In these places backwaters of small drainageways have added a deposit of finer material over a loose sand similar to that underlying the Lynden soil. The surface soil is brownish-gray granular clay loam, which grades first to gray and brown sandy clay and then, at about 18 inches, into a gray highly iron-stained firm loamy sand substratum.

BAUGH SERIES

The inextensive Baugh soil is confined to the area of pumice fall, where it occupies swampy areas and is associated with the Cispus soils. The surface soil is dark brownish-gray pumice, high in organic

matter and about 8 to 16 inches deep. The subsoil is loose pumice stained with yellowish brown, which at varying depths below 3 feet rests on gray or bluish-gray clay.

KOSMOS SERIES

The soil of the Kosmos series occupies imperfectly or poorly drained places in association with soils of the Glenoma series. Like the Glenoma soils, it occurs in Rainy Valley. Both the surface soil and subsoil are dark brownish gray or nearly black. The surface soil is granular and friable but dries to very hard angular clods and becomes more compact with depth. An 8- to 12-inch layer of mixed pumice and clay occurs within 18 to 24 inches of the surface, and pumice fragments are scattered through the surface soil in places. The lower subsoil is bluish-gray stiff clay mottled with rust brown and yellow.

SOILS OF ALLUVIAL FANS

The soils of alluvial fans belong to the Galvin and Nesika series. They occupy sloping fan deposits formed at the mouths of tributary streams rising on the outlying low hills and precipitous slopes of the higher mountains. The soils overlie the terraces along the major stream valleys or are on the alluvial flood plains. In some places they grade almost imperceptibly into the soils of the valley floor; in others they occupy slopes so steep that they contain significant quantities of colluvial material. The texture is dependent to a large extent on the slope. Where the gradient varies the soils may have different textures. The agricultural use and productiveness of these soils is variable within the series as well as within the group.

Soils of the two series are differentiated from one another by the origin of their parent material as well as by their profile characteristics. The Galvin soils are derived principally from materials originating from shale and sandstone, and the Nesika soils are largely from basalt. The soils of the Galvin series are imperfectly drained; those of the Nesika series are well to excessively drained.

GALVIN SERIES

Soils of the Galvin series have grayish-brown to brownish-gray granular surface soil, a yellowish-brown firm and slightly mottled subsoil, and a slightly compact clay substratum mottled and stained with gray, yellow, and brown. These soils occur in the western part of the county in association with soils of the Melbourne series. They occupy local alluvial fan deposits eroded from the Melbourne soils. Surface drainage is good, but seepage water from the adjacent shale hills penetrates the low fans and causes imperfect internal drainage.

NESIKA SERIES

Soils of the Nesika series occupy sloping alluvial fans in the eastern part of the county. They consist mostly of basic igneous materials, but near Randle they contain some pumice fragments. The surface

soil is dark brown, friable, fairly high in organic matter, and of a soft granular structure. The subsoil is firm and brown to yellowish brown. This layer grades into a gravelly substratum that contains enough interstitial soil material to prohibit excessive drainage except in the more gravelly soils. The surface and subsoil contain many angular and subangular basaltic gravelstones.

SOILS OF ALLUVIAL FLOOD PLAINS

The soils of alluvial flood plains—the most fertile and highly productive in the county—occupy main valley floors of the principal streams and rivers and many of the smaller tributary streams. Most of the soils are too high to be flooded annually, but they are inundated occasionally when the water is exceptionally high.

The group consists of the Chehalis, Newberg, Wapato, Reed, and Cove soils, which are derived from alluvium of mixed shale, sandstone, and basic igneous materials; the Pilchuck, Puyallup, Sultan, and Puget soils, which are derived from basaltic material and glacial rock flour; and the Siler and Schooley soils, which are derived from basaltic material and glacial rock flour influenced by pumice. Of these soils the Pilchuck are excessively drained; the Chehalis, Newberg, Puyallup, and Siler are well drained; the Wapato and Sultan are imperfectly drained; and the Reed, Cove, Puget, and Schooley are poorly drained.

CHEHALIS SERIES

Soils of the Chehalis series are on the main valley floor. They are brown, medium-textured, deep soils with a very granular and friable surface soil and a firm but not compact subsoil. The lower subsoil is a uniform, firm, permeable, yellowish-brown silty clay or silty clay loam to 4 feet or more. Chehalis soils occupy either first or second bottoms, depending on the size of the streams, and are subject to overflow only during occasional severe floods.

NEWBERG SERIES

Soils of the Newberg series occur principally along narrow first bottoms bordering stream channels and are usually subject to annual overflow. Their surface soil is medium brown to light brown and generally has a sandy texture. The subsoil has a lighter color and texture and grades into a yellowish-brown loamy sand substratum.

WAPATO SERIES

The Wapato soils occupy imperfectly to poorly drained positions intermediate between the Chehalis and Reed soils; the three compose a catena in drainage relationships. The Wapato soils occur in the back bottoms of larger valleys or in smaller valleys where drainage is restricted. The surface soil is grayish brown or brownish gray, granular, and friable. Yellow and rust-brown mottling occurs nearly to the surface. The subsoil is olive gray, highly mottled and stained, slightly compact, and slightly heavier than the surface layer. Below

2½ or 3 feet the subsoil grades to less stained and mottled grayish stratified clay, sandy clay, or silty clay.

REED SERIES

Soils of the Reed series occupy the low swampy back bottoms in association with the Chehalis and Wapato soils. The surface soil is dark gray or brownish gray, granular but relatively tight, and contains some rust-brown mottling. At 7 to 14 inches this layer grades into a highly mottled moderately compact gray clay that becomes at first gray and then, below 2 feet, bluish gray, stiff, and plastic.

COVE SERIES

The Cove soils occupy positions similar to the Reed soils but have a very dark-gray to black surface and subsoil. The surface soil is heavy, high in organic matter, and coarsely granular. The subsoil is a dark bluish-gray dense clay that has a blocky structure. The lower subsoil or substratum is a lighter gray but dense and stiff clay mottled with yellow and rust brown.

PILCHUCK, PUYALLUP, SILER, SULTAN, AND SCHOOLEY SERIES

The Pilchuck, Puyallup, Siler, Sultan, and Schooley soils are derived from recent depositions of the larger streams that carry large quantities of rock flour from melting glaciers. The parent material is from mixed materials and usually has a gray pepper-and-salt color. These soils occur along the Cowlitz River and to a small extent along the Nisqually River; they are described separately in the following paragraphs.

The Pilchuck soils occupy the narrow first bottoms adjacent to the main rivers and have a sandier texture than the Puyallup. They inherit a gray color from the parent material and maintain it throughout the profile. The soils have little development and change little with depth. They are excessively drained and droughty.

The Puyallup soils occur at higher levels than the Pilchuck and are subject to overflow only when the rivers are excessively high. Puyallup soils are grayish-brown or brownish-gray silty loams and fine sandy loams that grade to stratified deposits of olive-gray pepper-and-salt colored fine and coarse sands slightly compacted and only faintly mottled. The gray color is inherent and not developed. The soils are naturally fertile and not excessively droughty.

The Siler soils, which are the recent alluvial soils of the Cowlitz River Valley, occur principally in Big Bottom between Randle and Packwood in the eastern part of the county. The principal characteristic distinguishing the soils of the Siler series from soils of the Puyallup series is a layer of pumice, which usually occurs between 8 and 16 inches below the surface and is 4 to 10 inches thick. The surface soil is brown to yellowish or grayish brown, mellow, and friable. The subsoil below the pumice is light grayish brown, smooth and mellow, and grades at about 32 inches into stratified fine sand and silt. The soil is moderately well drained and generally has no mottling above 32 inches.

The Sultan soil is associated with the Puyallup and Puget soils and occupies a position intermediate between the two. It has a uniform silty texture in the surface and subsoil and is only faintly mottled in the lower subsoil.

The Puget soil is poorly drained and usually swampy and wet during most of the year. Its surface soil is light brownish-gray silt loam or silty clay loam, and the subsoil and substrata are gray interstratified silts and clays usually fairly highly mottled with rust brown and yellow and some blue.

Soils of the Schooley series are poorly drained hydromorphic associates of the Siler soils and occupy low back-bottom positions. They are characterized by a thin layer of pumice 8 to 16 inches below the surface. Their surface color is grayer than that of the Siler soils, and they are usually mottled nearly to the surface. The lower subsoil is of stratified silts and clays and is mottled with yellow and rust brown.

ORGANIC SOILS (IN DEPRESSIONS)

The organic soils—Rifle peat, Carbondale muck, and soils of the Snohomish series—are composed primarily of plant matter that has accumulated in shallow lakes or in permanently wet situations and is in various stages of decay. They are low in volume weight, high in water-holding capacity, usually high in total nitrogen, and low in potash. Supplies of other nutrients are variable. In this county the organic soils are inextensive and of only local agricultural importance, although the deeper deposits that have been well drained are fertile and highly productive.

RIFLE PEAT

Rifle peat consists of raw partly weathered acid woody plant remains and some sedges. Where this soil is deep and adequately drained, it produces fair to good crops.

CARBONDALE MUCK

Carbondale muck consists of well-decomposed woody plant remains and some sedges. Like Rifle peat, it is productive where it is deep and adequately drained.

SNOHOMISH SERIES

Soils of the Snohomish series are characterized by a 8- to 20-inch surface layer of grayish-brown mottled granular mineral soil over a peat or muck deposit. The mineral soil is derived principally from materials similar to those of the Wapato soils; however, some areas with material similar to that of the Puyallup soils are included.

SOIL TYPES AND PHASES

In the following pages the soils of Lewis County, identified by the same symbols as those on the soil map, are described in detail, and their agricultural relations are discussed. Their location and distribution are shown on the soil map, and their approximate acreage and proportionate extent are given in table 3.

TABLE 3.—*Approximate acreage and proportionate extent of the soils mapped in Lewis County, Wash.*

Soil	Acres	Percent
Baugh pumicy loam	301	(1)
Carbondale muck	280	(1)
Shallow (over dense clay)	1, 125	0. 1
Chehalis silt loam	4, 806	. 5
Mottled subsoil	437	(1)
Chehalis silty clay loam	11, 579	1. 2
Mottled subsoil	707	. 1
Cinebar silt loam:		
Gently rolling	11, 935	1. 2
Hilly	8, 345	. 8
Undulating	9, 190	. 9
Cispus pumicy sandy loam:		
Gently undulating	8, 916	. 9
Sloping	2, 899	. 3
Clackamas silty clay	361	(1)
Clackamas silty clay loam	1, 369	. 1
Cove silty clay	301	(1)
Cove silty clay loam	248	(1)
Doty silty clay loam	1, 473	. 1
Dryad silt loam	921	. 1
Dryad silty clay loam	511	. 1
Everson clay loam	127	(1)
Fitch gravelly sandy loam, undulating	626	. 1
Galvin loam, very gently sloping	940	. 1
Galvin silt loam, very gently sloping	1, 224	. 1
Galvin silty clay loam:		
Gently sloping	376	(1)
Very gently sloping	1, 358	. 1
Glenoma loam	1, 345	. 1
Glenoma silt loam	991	. 1
Grande Ronde silt loam, shot phase	356	(1)
Grande Ronde silty clay loam, shot phase	1, 683	. 2
Greenwater fine sand	3, 904	. 4
Greenwater loamy sand	1, 626	. 2
Greenwater sandy loam	295	(1)
Klaber-Olequa silty clay loams	1, 692	. 2
Klaber silt loam, gravelly subsoil	380	(1)
Klaber silty clay loam	4, 034	. 4
Gravelly subsoil	2, 147	. 2
Kopiah-Onalaska silty clay loams	1, 496	. 2
Kopiah-Salkum complex, sloping	2, 952	. 3
Kopiah silt loam	15, 214	1. 5
Kosmos clay loam	823	. 1
Lacamas silt loam	5, 681	. 6
Lacamas silty clay loam	5, 441	. 6
Lynden fine sandy loam	357	(1)
Made land	79	(1)
Melbourne-Meskill silty clay loams	17, 081	1. 7
Melbourne silty clay, hilly	3, 822	. 4
Melbourne silty clay loam:		
Hilly	110, 616	11. 4
Rolling	22, 792	2. 3
Steep and hilly	34, 407	3. 6
Meskill-Melbourne silty clay loams	1, 467	. 1
Meskill silt loam, sloping	315	(1)
Meskill silty clay loam:		
Moderately steep	232	(1)
Sloping	3, 756	. 4

[1] Less than 0.1 percent.

TABLE 3.—*Approximate acreage and proportionate extent of the soils mapped in Lewis County, Wash.*—Continued

Soil	Acres	Percent
Mossyrock silt loam	1,883	0.2
Nesika clay loam, seep phase	176	(1)
Nesika gravelly loam:		
Gently sloping	871	.1
Very gently sloping	219	(1)
Nesika loam:		
Gently sloping	712	.1
Very gently sloping	1,031	.1
Nesika soils, undifferentiated	5,096	.5
Newberg fine sandy loam	4,672	.5
Newberg loamy fine sand	844	.1
Newberg sandy loam	1,816	.2
Newberg silt loam	3,635	.4
Nisqually loamy sand	293	(1)
Olequa silt loam:		
Gently undulating	3,539	.4
Sloping	177	(1)
Olympic silty clay loam:		
Hilly	15,917	1.6
Rolling	13,745	1.4
Olympic stony silty clay loam:		
Hilly	396	(1)
Rolling	421	(1)
Onalaska silt loam	1,425	.1
Onalaska silty clay loam	2,828	.3
Pilchuck and Puyallup loamy sands	815	.1
Pilchuck gravelly sand	502	.1
Pilchuck loamy sand	1,180	.1
Over Puyallup fine sandy loam	453	(1)
Pilchuck sand	2,442	.2
Puget silt loam	279	(1)
Puyallup fine sandy loam	2,960	.3
Puyallup loamy fine sand	870	.1
Puyallup silt loam	1,272	.1
Reed clay	1,217	.1
Reed silty clay loam	2,610	.3
Riffe loam	749	.1
Riffe sandy loam	661	.1
Rifle peat	1,151	.1
Pumicy	698	.1
Shallow (over dense clay)	532	.1
Riverwash	3,535	.4
Rough broken land	3,126	.3
Olympic soil material	9,730	1.0
Rough mountainous land:		
Olympic and Cispus soil materials	20,589	2.1
Olympic soil material	259,929	26.5
Olympic, Wilkeson, and Cispus soil materials	79,691	8.2
Wilkeson soil material	56,859	5.9
Salkum silty clay loam:		
Deep, nearly level	6,827	.7
Moderately steep	17,842	1.8
Rolling	30,664	3.1
Rolling, deep	967	.1
Undulating	44,329	4.6
Scamman-Lacamas complex	928	.1
Scamman silt loam	455	(1)
Scamman silty clay loam	1,806	.2
Schooley loam	361	(1)

[1] Less than 0.1 percent.

TABLE 3.—*Approximate acreage and proportionate extent of the soils mapped in Lewis County, Wash.*—Continued

Soil	Acres	Percent
Schooley silt loam	1, 185	0. 1
Siler fine sandy loam	2, 577	. 3
Siler silt loam	2, 119	. 2
Snohomish silt loam, pumicy	423	(1)
Snohomish silty clay loam	132	(1)
Spanaway gravelly sandy loam	3, 044	. 3
Sultan silt loam	329	(1)
Tower silty clay loam	2, 047	. 2
Vader loam, hilly	3, 271	. 3
Wapato-Chehalis silty clay loams	302	(1)
Wapato-Galvin complex	276	(1)
Wapato silt loam	1, 626	. 2
Wapato silty clay loam	19, 467	2. 0
Wilkeson silt loam:		
Hilly	1, 007	. 1
Rolling	4, 149	. 4
Winlock silt loam, gently undulating	782	. 1
Winlock silty clay loam:		
Gently undulating	2, 444	. 2
Level	3, 324	. 3
Sloping	298	(1)
Winston gravelly loam, gently undulating	2, 440	. 2
Winston gravelly sandy loam:		
Gently undulating	1, 061	. 1
Moderately steep	329	(1)
Sloping	179	(1)
Winston loam, gently undulating	2, 283	. 2
Winston silt loam, nearly level	1, 362	. 1
Total	987, 520	100. 0

[1] Less than 0.1 percent.

Baugh pumicy loam (BA).—This soil, of only minor importance and local distribution, occurs in the deep pumice area in the eastern part of the survey, where it occupies depressions and poorly drained areas along small drainageways. It is associated with soils of the Cispus series.

The 8- to 14-inch surface soil consists of dark brownish-gray weathered pumice and organic matter and has a gritty pumicy loam or pumicy sandy loam texture. The quantity of unweathered pumice and content of organic matter vary within short distances, and in places the surface soil contains an admixture of overwashed mineral material. The material becomes increasingly lighter, coarser textured, and lower in organic matter to a depth of 18 or 20 inches, where it rests upon loose pumice characterized by yellowish-brown iron stains. This pumice layer continues for 2 or 3 feet to a clay substratum that is gray highly stained with blue.

Use and management.—The total area is small, and none of the soil is cultivated. The cover is a heavy growth of mixed conifers and deciduous trees, brush, and shrubs, below which grows a heavy undercover of sedges, grasses, spiraea, wild rose, and other water-loving plants. The soil is nearly always saturated.

Carbondale muck (CA).—Only a small acreage of normal-depth Carbondale muck occurs in the county. Nearly all the muck area is mapped as Carbondale muck, shallow (over dense clay). The principal areas are highly saturated and usually flooded in winter and early in spring.

The organic matter of this muck soil is more decomposed and contains fewer recognizable plant remains than Rifle peat. The surface soil, extending to a depth of 8 to 12 inches, is dark grayish-brown or nearly black granular and relatively greasy woody muck that contains some silty mineral soil. This layer is derived principally from woody peat but probably includes sedge and colloidal peats. The deposits vary in composition with each area. Below the surface soil occur dark-brown or brown woody sedge peats or mixtures of both; these grade into a lower subsoil that contains mixtures of woody, sedge, and colloidal materials. At varying depths below 2½ feet this subsoil material lies on bluish-gray highly colloidal clay.

Use and management.—The natural vegetation on Carbondale muck is similar to that on Rifle peat. The soil must be drained before it can be used. As do peat areas, this muck soil tends to settle when drained and cultivated. All the areas are used for pasture grasses, principally Reed canarygrass. Farm practices are similar to those for Rifle peat. The organic remains have reached a more advanced stage of decay than those in Rifle peat, and consequently this soil is somewhat higher in fertility.

Carbondale muck, shallow (over dense clay) (CB).—The principal areas of this soil are commonly associated with the Reed soils or border deeper deposits of peat and muck. Aside from depth this phase is very similar to Carbondale muck, but it is much more extensive and more widely distributed.

The soil consists of a surface layer of dark-grayish brown or nearly black well-decomposed plant remains that are granular but have a greasy feel. Usually the surface soil is fairly shallow, especially in the valley of Hanaford Creek, where it grades at 5 to 10 inches into a dense stiff blue clay similar to that of the Reed soils. In Pleasant Valley and other areas the normal depth to the blue clay substratum is 16 to 24 inches.

Use and management.—Carbondale muck, shallow (over dense clay), is poorly drained and swampy. Its shallowness and dense clay substratum make it less easily drained and less desirable than Carbondale muck. Nonetheless, it is fertile and gives good yields where drainage is favorable. It is used mostly for pasture but in some areas for hay and grains. Natural vegetation and farm practices are similar to those on Carbondale muck, but yields are not so good.

Chehalis silty clay loam (CE).—This is an extensive well-drained brown deep alluvial soil occupying better drained positions on the alluvial flood plains of those streams and rivers that carry materials derived primarily from sandstone, shale, and basalt. It occurs in the valleys of the Chehalis and Newaukum Rivers and their tributaries and is one of the most important agricultural soils of the county (pl. 1, *A*).

The surface soil is slightly acid brown or dark brown very granular and friable silty clay loam. At 12 to 18 inches this layer grades to lighter brown, firm or slightly compact but friable, moderately acid silty clay having a very granular structure. At 24 to 32 inches there is a brown to yellowish-brown silty clay or light clay—slightly less compact, less granular, and lighter colored. Below 40 or 48 inches there is a relatively uniform slightly acid brown or yellowish-brown light clay or heavy silty clay that is permeable, slightly granular, and faintly mottled with rust brown and yellowish brown.

The surfaces of the granules have a strongly developed colloidal coating. It is not uncommon for the lower part of the profile to be stratified with fine sand. Subsoil mottling is not characteristic and is only faint where it does occur. Internal drainage is moderate, and the fairly level to slightly undulating topography permits adequate surface drainage. The soil is subject to overflow only during occasional very high floods.

Use and management.—A high percentage of Chehalis silty clay loam is farmed, the greater part being in cultivated crops and the rest in permanent pasture. The soil is inherently fertile and fairly high in active organic matter. As it warms up early in spring, it provides a long growing season. The granular structure and very friable surface soil allow it to be tilled throughout a wide range in moisture conditions, but it is not so easily tilled as the Puyallup soils. The soil retains moisture enough to mature crops, although permanent pasture and late or second crops of hay are often damaged during dry summers.

The principal crops are small grains, hay, and pasture grown by dairy farmers. Except for a few farmers near Chehalis operating on a commercial basis, most farmers grow vegetables only for local consumption. The soil appears to be well adapted to peas for canning and frozen pack, and acreages in this crop have increased considerably in the last few years. Only very limited quantities of potatoes are grown, for the flea beetle and diseases reduce their yield and market value.

The common grass hay crop—red or alsike clover with Italian ryegrass or timothy—produces 2½ to 4 tons an acre. Alfalfa, more commonly grown on this soil than any of the other legumes, yields 3 to 5 tons. It is more easily established, and once it has been started, maintains itself well. Oats produce 1½ to 3 tons of hay and 60 to 80 bushels of grain. Mixed with hairy or common vetch, oats yield 3 to 5 tons. They are often planted with clover or grass hay as a nurse crop, but the second crop of hay frequently gives seriously reduced yields and must be harvested fairly early to avoid depleting the reserve supply of moisture. Planting oats as a nurse crop for hay seedings is not usually recommended.

Spring and winter wheat are common crops and yield 35 to 50 bushels (pl. 1, *B*). Other grains are barley and rye, planted in small acreages. Peas yield 2,000 to 4,000 pounds, particularly where irrigated.

Irrigation of these soils is still largely in the experimental stage, although several farms have installed sprinkler systems (pl. 1, *C*). The primary requisite for irrigation is an adequate supply of water

A, Part of the Chehalis River bottom. Most of the farms are on Chehalis silty clay loam. Mainly Melbourne soils on surrounding hills; Olympic soils on higher mountains in upper right corner.
B, Wheat on Chehalis silty clay loam, a fertile and productive soil.
C, Typical sprinkler irrigation on Chehalis silty clay loam.

A, Typical hillside of Cinebar silt loam, gently rolling; Klaber silty clay loam in level foreground.
B, Filbert orchard on Cinebar silt loam, gently rolling.

close to the farm—usually a main stream or river. Well water is not sufficient in most places. The fields are irrigated entirely by overhead sprinklers. Irrigation increases yields and makes them more certain. The carrying capacity of permanent pastures is more than doubled by irrigation. Other advantages are the flexibility possible in the time of planting under different rotation systems and the higher efficiency obtained in the use of the land.

Considerable quantities of barnyard manure are used. Sometimes manure supplemented with commercial fertilizers is applied, especially to irrigated soil that is cropped heavily. Mixed hay yields are materially increased by adding 800 pounds of 5–10–5 [3] fertilizer where nonleguminous crops were raised the year before or, where legumes were grown or applications of barnyard manure were made the year before, 20 pounds of nitrogen and 40 pounds of available phosphoric acid.

Oat hay following a legume crop or on fields that have received barnyard manure is improved by applying 400 pounds of 5–10–10. If the oat hay follows a nonlegume or was not manured, 800 pounds of 5–10–10 should be the application. Canning peas usually receive 40 pounds of nitrogen, 120 pounds of available phosphoric acid, and 80 pounds of potash or, after leguminous crops or previous barnyard manure, an application of 80 pounds of available phosphoric acid. Beneficial results are also obtained by reinforcing barnyard manure with about 250 pounds of 20-percent superphosphate and 100 pounds of sulfate of ammonia for each 6 tons of manure.

Chehalis silty clay loam, mottled subsoil (Cf).—The few areas of this soil occur mostly along the Chehalis River. The noticeably mottled subsoil and substratum cause them to be classified separately as the mottled subsoil phase.

This soil is less permeable than Chehalis silty clay loam and has a slightly heavier textured subsoil. At 20 to 40 inches the subsoil is mottled; below 40 inches it is distinctly mottled and somewhat plastic.

A number of areas of Chehalis silty clay loam occurring in narrow valleys have profiles similar to this soil, but they are not shown on the soil map, mainly because they are not uniform and range widely within short distances. It would take an exceedingly long time to map them accurately.

Use and management.—Chehalis silty clay loam, mottled subsoil, is better for most farm crops during dry years than Chehalis silty clay loam, but it is more difficult to manage when precipitation is greater than normal.

Chehalis silt loam (Cc).—This soil is less extensive than Chehalis silty clay loam, but farmers consider it slightly better for most crops. It usually occupies smaller areas closer to the stream channels and in many places owes its surface texture to greater deposition of silty material over the silty clay loam profile.

The surface soil, to a depth of 10 or 12 inches, consists of brown, rich brown, or slightly dark-brown granular and friable silt loam. This surface layer grades into lighter brown or slightly yellowish-brown

---

[3] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

friable and granular silt loam, which continues to depths of 24 to 36 inches. Next occurs a brown or slightly yellowish-brown silty clay loam, firm to very slightly compact but permeable, that breaks into small colloid-coated irregular granules. This silty clay loam is usually uniform for several feet, but in a few places it is stratified with silt and fine sand.

The subsoil is typically not mottled or is only faintly mottled above 3 feet; however, in several small areas in the smaller valleys it is mottled below 18 inches and in places even within a foot of the surface. Gradation zones occur between this soil and the Wapato soils, and in these the subsoil is often mottled.

Included with the soil are several areas totaling 400 or 500 acres, also in smaller valleys, that have a loam surface soil and more gritty but otherwise similar subsoil and substratum.

Use and management.—In kinds of crops, yields, and fertilizer practices Chehalis silt loam is similar to Chehalis silty clay loam. The lighter texture makes for easier tillage, and the moisture-holding capacity is only slightly reduced. This soil is much better for truck crops than Chehalis silty clay loam. Nearly all the land has been cleared for cultivated crops. The original timber consisted of a heavy stand of large fir, hemlock, and cedar, many alder and maple, and a heavy undercover of brush and shrubs. The few uncleared areas support a heavy cover of similar trees.

Chehalis silt loam, mottled subsoil (CD).—The few areas of this soil occur in small valleys and along the Chehalis River. The mottled subsoil and substratum are apparently the result of poor subsoil aeration caused by imperfect drainage.

The surface soil is lighter textured and more friable, but in other profile characteristics this soil is similar to Chehalis silty clay loam, mottled subsoil. It is easier to till because it is lighter textured, but crop yields on the two soils are similar.

Cinebar silt loam, gently rolling (CG).—One of the best of the uplands or old terraces, this deep well-drained soil occupies gently rolling relief in the central part of the county, where the elevation ranges from 900 to about 1,100 feet. Slopes range from 5 to 15 percent but are usually 6 to 10 percent.

In virgin conditions the surface 2 to 2½ inches is a partly decomposed very strongly acid organic mat of moss, twigs, and leaves. The surface soil, continuing to a depth of 10 or 12 inches, is brown or dark-brown mellow and friable medium acid silt loam. It is distinctly granular and contains many small shotlike pellets. The surfaces of the granules are darker than the interiors.

The upper subsoil is mellow, uniform, light yellowish-brown silt loam that below 3 feet becomes a slightly darker colored lighter textured firm but mellow light yellowish-brown material. At an average depth of about 6 feet the yellowish-brown material grades into yellowish-gray gritty silty material containing strongly weathered gravel. The gravel is partly cemented and stained with rust brown. At variable depths below 6 feet, but usually not more than 8 feet, this silty material in places rests on a deposit of gray or yellowish-gray partly cemented gravel and fine sand, which is several feet

thick and may occur in 6- to 12-inch lenses. The gravel is subangular and firm and of mixed andesitic, basaltic, and granitic origin. The layer of gravel and fine sand appears to be a relatively thin and partly cemented till; it does not occur regularly and, in most areas, is absent. Some rounded gravel may occur on the surface or in the solum but this is not typical.

Included with this soil is an area of about 400 acres on gently rolling relief about 1 mile northeast of Silver Creek. It has a slightly heavier textured surface soil and subsoil than typical Cinebar silt loam soils. The subsoil of this included area appears to be slightly compact, but the land is used in much the same way as Cinebar silt loam soils.

The origin of this Cinebar soil is not certain. Several explanations appear plausible. The most probable is that the soil is derived from fine-grained weathered pumice and has been influenced to some extent by glacial action and possibly to a degree by loess. In some places strongly weathered fragments of pumice occur throughout the entire profile.

Use and management.—Some of Cinebar silt loam, gently rolling, is still in virgin forest that is rapidly being logged. The growth is heavy and dominantly of Douglas-fir, although hemlock and cedar are also present. The virgin timber now remaining is of poor quality. The undercover consists principally of ferns, salal, Oregon grape, red huckleberry, and vine maple. Logged areas are quickly covered with deciduous trees, brush, ferns, and young fir trees.

The principal areas cultivated are near Silver Creek and Mossyrock (pl. 2, *A*). As dairying is the principal farm industry, most of the crops are used for dairy feed. The common hay crops are oats, clover, clover and grass, and mixtures of oats and legumes. Oat hay yields 1½ to 2 tons an acre; mixtures of oats and vetch or of oats and peas, as high as 4 to 5 tons. Clover is more easily established and maintained than on the Salkum soils and is commonly grown for hay, seed, and pasture. Oats are not commonly used as a nurse crop, for they often deplete the moisture content of the soil so much that clover is damaged and may die out late in summer. A mixture of red, white, and alsike clovers with ryegrasses and timothy is commonly used. This mixed stand is usually cut for hay rather than pastured. Some corn is grown for silage and produces good yields. In a few places potatoes are planted late to escape flea beetle infestations, but yields are precarious and low.

Most of the deciduous fruits are grown for home consumption. The fruit is of good quality, and the trees are healthy. This deep permeable soil is much better adapted to orchard crops than the Salkum soils, and it is also well adapted to filbert growing. One of the better and older filbert orchards of the county occurs on this soil near Silver Creek (pl. 2, *B*).

Like all the old soils of the county, the available nitrogen content of this soil is low, and the use of barnyard manure, crop residues, or legumes in crop rotations is necessary to insure good yields. Nitrogen and phosphate fertilizers produce good responses. Other fertilizers or amendments have not proved beneficial. Generally, nitrogen is supplied through farm manure. Crops respond if 20 to 40 pounds of

nitrogen, in the form of nitrate of soda or sulfate of ammonia, is applied with manure or if 60 to 80 pounds of nitrogen is applied without manure. Phosphate fertilizers are best when added to the soil with some source of nitrogen, which may be in commercial fertilizers or barnyard manure. The usual procedure is to apply about 300 pounds of superphosphate the first time and follow yearly with 250 pounds.

Alfalfa in greenhouse pots was treated in various ways with differing results (see plate 6, *B*). Complete fertilizer brought the best response, but results from manure with a phosphate fertilizer were nearly as good. Lime applied at the rate of 3 tons an acre was not particularly beneficial, and application of phosphorus alone did not appear to be adequate. Superphosphate containing calcium and sulfur was more effective for alfalfa than treble-superphosphate, in spite of the additional availability of treble-superphosphate. Potash did not appear to be particularly beneficial.

Cinebar silt loam, undulating (CK).—This soil is distinguished from the gently rolling phase principally by its steepness of slope. Slopes average under 5 percent, as compared to 15 percent for the gently rolling phase. In an extensive area between Silver Creek and Cinebar, however, the average slope is about 5 percent. This soil occupies about the same total area as Cinebar silt loam, gently rolling.

This soil has slightly better relief for crops than the gently rolling Cinebar silt loam, but yields and cultural practices are practically the same on both.

Cinebar silt loam, hilly (CH).—Slopes for this soil are generally more than 15 percent but usually less than 30. The irregular areas, occurring on short steep slopes or as large tracts with strongly rolling relief, are distributed throughout the general area of Cinebar soils.

Use and management.—Surface drainage on Cinebar silt loam, hilly, is more rapid than on the gently rolling phase. Erosion is well controlled under the native cover but probably would be accelerated under cultivation. On the steeper slopes the soil is usually thinner, and gravel and stone are more common. These unfavorable features limit its use principally to forest. Under favorable circumstances timber trees restock rapidly, but some of the lighter areas could profitably be reseeded. Under proper management some areas might be used in conjunction with cultivated land for supplementary grazing. The grazing capacity of areas burned over or partly cleared could be increased by seeding grass-and-clover mixtures to supplement the native grasses and clovers. Much of the land that has been logged and is now slowly restocking could be used for grazing to good advantage if it were seeded.

Cispus pumicy sandy loam, gently undulating (CL).—This soil occupies smooth gently undulating terraces lying above overflow between Kosmos and Randle in the eastern part of the county. It consists of a layer or layers of pumice material averaging 2½ to 4 feet deep over terrace soils similar to those of the Glenoma or Winston series (pl. 3, *A*).

The typical soil has a 1½- or 2-inch layer of organic matter consisting of twigs, leaves, cones, moss, and humus. Immediately under the organic layer there is often a ¼- to ½-inch layer of light-gray

podzolized ashy material. The surface soil, extending to a depth of 6 to 8 inches, consists of a grayish-brown gritty sandy loam of weathered pumice and organic matter, the lower inch or two of which is slightly mottled with yellow and rust brown. The surface soil rests upon a loose porous deposit of pale-yellow pumice fragments ranging from the size of a small pea to fragments up to 2 inches in diameter. The pumice, originally nearly white, is now stained yellowish brown and slightly rust brown. Because of their vesicular structure and light weight, the larger pumice fragments will float on water for some time when dry. At varying depths between 32 and 48 inches the pumice rests abruptly upon a light yellowish-brown loam or silt loam substratum that is free of pumice and faintly discolored with light-gray and yellowish-brown mottling. The inch or two of pumice just above the underlying material is in many places relatively light colored. The soil material underlying the pumice usually grades into a gravelly substratum at depths of 5 to 15 feet.

The depth of the pumice deposit ranges from 18 inches deep in the outlying areas to as much as 10 feet or more on the south side of the Cowlitz River. The pumice deposited in small areas along the Nisqually River is much more highly discolored with rust brown and yellow than the rest, and the deposit averages about 18 inches thick. Towards Randle a thin layer of much finer and whiter pumice—evidently from a later pumice deposition—covers the surface.

Use and management.—The roots of forest trees apparently are able to penetrate the pumice in Cispus pumicy sandy loam, gently undulating, and obtain moisture from the material below. The pumice acts as a mulch, preventing the drying out of the underlying soil. Many cedars and maples grow in association with the Douglas fir, which attains a large size in a short time (pl. 3, *B*). Underdrainage seems to be free but is not rapid. Most of the soil is in virgin timber; very little of it is cleared and farmed. The pumice is so loose and porous that the soil is much better suited to timber than to most crops. Some areas adjacent to cultivated bottom soils are used for building sites, for the bottom soils are occasionally flooded.

Cispus pumicy sandy loam, sloping (Cm).—This soil is associated with the gently undulating phase but differs principally in having sloping relief (5 to 15 percent). A few short slopes of more than 15 percent are included. In all other respects the two soils are very similar. Water absorption is very rapid on the sloping soil, but its variations in relief are of minor importance in profile development or use.

About 1 square mile is mapped in which the Cispus soil covers material similar to that of the Wilkeson soils rather than material on river terraces.

Clackamas silty clay loam (Co).—Although not extensive, this soil is widely distributed over the county as nearly level depressional areas on stream terraces or postglacial stream terraces. It is commonly associated with soils of the Winston series, and to a lesser extent, with those of the Doty and Onalaska. It is differentiated from the other poorly drained soils of the river terraces by its very dark grayish-brown or nearly black surface soil and upper subsoil.

The surface 6 or 8 inches is very dark grayish-brown or nearly black heavy silty clay loam—granular, fairly friable, and high in organic matter. Next occurs a dark brownish-gray slightly compact but permeable clay having a granular or irregular nut structure and yellow and rust-brown mottling. At depths of 16 to 22 inches, the material just described grades into the lower subsoil, a brownish-gray clay less compact than that above, which has an angular nut or blocky structure and is more highly mottled with yellow, orange, and rust brown. Between 26 and 34 inches is very highly stained mottled clay variegated with gray, yellow, and rust brown. This clay is firm but not compact and has a mealy feel when wet. Rounded gravelstones are scattered in places in the upper part of this clay, and usually at 3½ to 5 feet the clay rests upon a compact substratum of gravel and clay. Scattered gravelstones are fairly common throughout the solum and on the surface.

A few areas in which the gravelly substratum is within 12 or 14 inches of the surface are included. The principal areas of this inclusion are as follows: About 40 acres 2½ miles southwest of Salkum or in the northwest quarter of section 23, township 12 north, range 1 east; about 10 acres 2 miles east of Cinebar Post Office; about 15 acres 4 miles northeast of Onalaska or in section 23, township 13 north, range 1 east; and a few scattered areas southwest of the Ethel radio-air beacon. In places small patches of soil that have a clay surface and are too small to separate are also included. Areas shown on the map with gravel symbols have a large quantity of gravel on the surface and are fairly shallow.

Use and management.—Nearly all areas of Clackamas silty clay loam have been logged; those that have not been cleared support a very heavy growth of maple, ash, alder, and other deciduous trees, brush, and shrubs and scatterings of cedar, hemlock, and fir. Probably less than a square mile is cleared and farmed. The soil is fertile and relatively productive when moisture conditions are favorable, but it must be drained before it can be used successfully for cultivated crops. Open ditches are more effective than tile because the clay subsoil is heavy. The moisture-holding capacity is usually sufficient to mature crops; the limiting factor is oversaturation of the soil during winter and spring. The principal crop is a mixture of ryegrass, timothy, and alsike clover that may also contain some Kentucky bluegrass, orchard grass, and white and red clovers. The first crop is usually cut for hay, and the field is then pastured.

Clackamas silty clay (Cn).—Except for its heavy and less friable clay surface soil and a more compact upper subsoil, this soil is similar to Clackamas silty clay loam. Cultivation is difficult, and the soil dries and cracks into relatively large blocks. Drainage conditions are poor. The soil is difficult to drain. Only a few acres have been cleared, these principally for pasture.

Cove silty clay (Cp).—This inextensive soil occupies low swampy poorly drained positions similar to those occupied by the Reed soils, but it differs from them in the color of its surface soil and upper subsoil. It occurs in association with the Chehalis soils.

The surface soil, 12 to 16 inches deep, consists of very dark brownish-gray or nearly black stiff heavy silty clay of high organic-matter

content. It has coarse angular granular structure and on drying often cracks and breaks into large irregular blocks. A 1- or 2-inch layer of highly organic material or sedge peat often occurs on the surface in virgin conditions.

The upper subsoil consists of nearly black very dense clay that has a massive structure and a few rust-brown spots. This layer usually ranges from a few inches to more than a foot thick; in some areas, however, the surface soil grades abruptly into the lower subsoil material. At 24 to 36 inches occurs the lower subsoil—a yellowish-gray or slightly bluish-gray slightly compacted clay strongly mottled with yellow, rust-brown, light-gray, and dark-brown organic stains. This layer is less compact than the layer above, but fairly dense. Strata of sandy clay often occur in the lower part.

Use and management.—In its natural condition this soil supports a heavy deciduous cover of maple, willow, alder, and ash and a dense undergrowth of brush and shrubs, including wild rose, spiraea, and water-tolerant grasses and sedges.

The soil is fertile, but production of crops is limited by drainage similar to that of Reed clay and by difficulty of tillage. In favorable years oats and hay produce high yields. The soil areas saturated during winter are cold and cannot be planted early in spring. The dense subsoil limits internal moisture movement, and the surface tends to dry fairly quickly. Crop failures are fairly common. In general the soil is used in much the same way as Reed clay. The principal hay crops are ryegrass, alsike clover, and timothy. Native bentgrass is also cut for hay or used for pasture.

Cove silty clay loam (Cr).—The few small areas of this soil occur in association with Cove silty clay. The surface soil is fairly friable nearly black silty clay loam high in organic matter. This layer grades into a dark-gray clay subsoil at 14 to 18 inches. The substratum is bluish-gray plastic clay.

Crops and yields are similar to those on Cove silty clay, but tillage is slightly easier.

Doty silty clay loam (Da).—The principal areas of this soil developed under a grass-and-fern prairie cover from old river terrace deposits. They are in the western and south-central parts of the county.

The 10- to 14-inch surface layer is very dark-brown granular friable silty clay loam, almost black when wet. This layer is underlain by 10 to 14 inches of dark-brown slightly compact coarse granular silty clay loam. The subsoil, which extends downward 36 to 48 inches, is brown or moderate-brown firm coarsely granular clay loam. The surfaces of the particles are much darker than the interiors. Small angular or subangular gravelstones, dominantly of basic igneous origin, are scattered throughout the surface soil and in increasing quantities in the subsoil. Underlying the subsoil is yellowish-brown fairly compact gravelly loam that extends to 60 inches or more and at lower depths grades into a mixture of gravel, sand, and soil material. This mixed material is of varying origin but predominantly basic igneous. The gravelstones are coated with colloids and strongly stained with rust brown and dark brown.

On Layton Prairie the parent materials of the soil are not so strongly basic as those in the other areas and the substratum is slightly more compact; otherwise the profile is relatively similar. Included are a few small areas of other soils that occur on more youthful terraces and commonly contain more gravel throughout the profile.

Use and management.—Although conditions are favorable for forest vegetation, Doty silty clay loam persists under a cover of grass, scattered bracken, and a few oaks. The dominant slope is 2 to 5 percent, and surface drainage is well established. Internal drainage is complete but not excessive. The slight compaction in the lower subsoil and upper part of the substratum aids in conserving moisture.

As these prairies did not have to be cleared, they were among the first areas in the county to be tilled. In the virgin state this soil was fertile and naturally productive, but after being planted in depleting crops over a long period of years, it gradually lost much of its fertility. The principal deficiency is lack of organic matter and nitrogen. Additions of manure and crop residues or a system of crop rotation containing legumes is necessary to keep fertility at a satisfactory level. The common application is about 60 pounds of nitrogen an acre in the form of commercial fertilizer, although 20 to 40 pounds is beneficial if added with manure or after a legume rotation. Crops respond materially to phosphate fertilizer added with manure or some other source of nitrogen at the rate of 60 to 80 pounds of available phosphoric acid an acre. Lime or other fertilizing elements have not proved particularly beneficial.

Hay, grain, and pasture are the principal crops. Wheat and oats are the common grains. Winter wheat yields 25 to 35 bushels to the acre; oats, 50 to 60 bushels. Oat hay yields 1 to 1½ tons an acre alone or 2.5 tons with vetch. Clover and alfalfa grow more successfully on this soil than on any of the other old soils. They are used principally for hay and pasture, although some red clover is grown for seed. The common practice is to cut two crops of hay, then pasture the field. A system of crop rotation that includes legumes is more easily used on this soil than on many of the others, for it has better adaptability to these plants, especially to clover and alfalfa.

Dryad silt loam (Db).—This soil is widely distributed throughout the county in association with those of the Olequa series. It occurs on recent terraces where drainage is slightly restricted or imperfect. In typical locations it occupies a position intermediate between Olequa silt loam, gently undulating, and Klaber silty clay loam. The three form a catena, or group, of soils developed from similar parent materials and differentiated from each other chiefly by differences in drainage.

The surface soil is light brownish-gray or pale-brown granular and friable silt loam. The outside of the granules is more grayish than the inside, and the soil is brown when finely crushed. In virgin areas the soil is covered by 1 or 1½ inches of leaves, twigs, and partly decomposed organic matter. Underlying the surface soil at a depth of 8 to 10 inches is pale-brown or very pale-brown silt loam faintly mottled with lighter gray and darker brown. This layer is slightly compact but breaks easily to small irregular fragments. It grades at varying depths (16 to 24 inches) into a yellowish-brown silt loam

or very fine sandy loam that is slightly compact and breaks to irregular fragments. Rust-brown staining occurs along the many root channels, and some yellowish-brown and light-gray mottling appears throughout. At varying depths between 32 and 38 inches this layer of silt loam or very fine sandy loam rests on smooth partly laminated silt, very fine sand, and silty clay, which are light yellowish brown and moderately stained and mottled with rust brown, yellowish brown, and light gray.

In places the soil occupies gently sloping terrace remnants. On these terraces seepage water from higher areas saturates the soil and keeps it from being perfectly drained. Where small darker colored patches occur the subsoil is heavier and more compact. The gradation between this soil and Klaber silty clay loam is gradual. In many areas the two soils are very similar. Slight changes in elevation of the microrelief, however, usually cause the surface soil to vary from grayish brown to pale brown and differ in the degree of mottling.

Use and management.—All areas of Dryad silt loam have been logged. The uncleared areas are supporting a second growth of Douglas-fir, hemlock, and cedar. Scatterings of alder and maple and an undercover of fern, salal, snowberry, willow, spiraea, and wild rose are usually associated with these conifers.

Drainage conditions are more variable than on either the associated Olequa silt loam, gently undulating, or Klaber silty clay loam. Surface drainage is generally slow, and internal drainage is partly restricted. Drainage is commonly improved by tile or open-ditch drains, and where these have been constructed the soil is used successfully for hay crops, permanent pasture, and small grains. The improvement of moisture conditions helps alleviate the effects of drought during summer, and except when winter rains are excessive, the soil does not become waterlogged. The principal hay crop is red clover or alsike clover mixed with ryegrass and timothy. Hay crops are usually pastured after the first cutting. Permanent pastures are seeded to clover-and-grass mixtures. Stump lands are often seeded to a similar mixture after a burn and used for supplementary pasture.

Under cultivation the soil is depleted of organic matter and nitrogen and must receive applications of these fertilizers if yields are to be satisfactory. Farmers generally use barnyard manure, a rotation including legumes, or green-manure crops to supply the necessary organic matter and nitrogen. If used with barnyard manure or following legumes, phosphate fertilizer applied at the rate of 60 or 80 pounds of available phosphoric acid an acre is beneficial. Used without manure or on soil not previously cropped to legumes, nitrogen applications should be at a ratio of approximately 1 to 1 with the phosphate for best results.

Dryad silty clay loam (Dc).—Although less extensive than Dryad silt loam, this soil is as widely distributed. It is associated with Dryad silt loam, which it closely resembles in most respects, but it usually has more restricted drainage, a grayer surface soil, and a slightly more compact subsoil.

The surface soil, extending to depths of 12 to 16 inches, is brownish-gray or light brownish-gray silty clay loam that tends to form small

clods and then break into angular fragments much lighter colored on the inside than on the surface. Rust stains follow root channels nearly to the surface. Underlying the surface layer is light yellowish-brown or yellowish gray-brown silty clay or silty clay loam subsoil that breaks relatively easily to small irregular crumbs. The rust-brown and yellow mottles and stains in this layer vary in intensity but are usually pronounced. The subsoil is firm but not compact and is permeable to roots and water. At depths of 30 to 40 inches the subsoil grades into a light yellowish-brown mellow silt and silty clay substratum similar to that underlying Dryad silt loam.

Use and management.—The land must be drained before it can be successfully cultivated, but it is more easily drained than Klaber silty clay loam. Only a small percentage is being farmed. Hay and pasture are the principal crops, and management practices are similar to those on Dryad silt loam.

Everson clay loam (EA).—The area covered by this soil is small. It occupies low swales in association with the Lynden fine sandy loam, its impaired drainage making it a hydromorphic associate of that soil. The surface soil to a depth of a foot or two is probably dominated by local overwash materials.

The surface soil consists of 8 to 12 inches of brownish-gray friable and slightly granular clay loam containing a small quantity of fine sand. It grades into a lighter brownish-gray slightly compact fine sandy clay variegated with iron stains and yellowish-brown mottling. At 18 to 20 inches is pale-brown or gray highly rust-stained fine sand, partly cemented in spots or containing disseminated ortstein. Below 36 inches this layer usually grades into a slightly compacted or firm, gray, pepper-and-salt sand with dark-brown stains.

Use and management.—Everson clay loam supports the heavy cover of second-growth deciduous trees, brush, shrubs, and grass common to the poorly drained soils. Excessive surface water is usually drained off by open ditches. Only a small acreage is cleared for cultivated crops, principally hay and pasture. Yields on this soil are usually higher than on the associated Lynden, Spanaway, or Nisqually soils because the moisture content is greater during the dry season.

Fitch gravelly sandy loam, undulating (FA).—This soil has developed on smoothly undulating glacial outwash plains, and its origin is similar to that of the Spanaway soils. Under a parklike forest cover, it has developed a surface soil intermediate in color between the dark prairie soils and the light-colored forest soils.

The 10 to 12 inches of surface soil under an inch or two of partly decomposed organic matter is fairly loose brown or dark-brown gravelly sandy loam or loamy sand containing many roots. This surface soil grades through a 10- or 14-inch transitional zone, where it becomes lighter in color and texture, to a light yellowish-brown and gray pepper-and-salt sand and gravel substratum that is very loose and porous. The gravel is of mixed origin and contains pebbles from a wide variety of sources. The larger gravelstones are well rounded; some of the smaller ones and some of the sand particles are relatively angular and dominantly basic, indicating an admixture of some materials of more local origin.

Use and management.—The original cover of Fitch gravelly sandy loam, undulating, consisted of scattered Douglas-fir, lodgepole pine, and oak and an undercover of brush, shrubs, and grass. All the land has now been logged, but very little of it is cleared for farming. The soil is very droughty, and plants may not mature for lack of moisture in dry years. Early maturing crops are more successful, but yields are low. Pastures have a low carrying capacity, and the grazing period is short.

Galvin loam, very gently sloping (GA).—Although this soil is better drained than Galvin silty clay loam and silt loam soils, it is similar in origin and position. It usually occupies very gently sloping alluvial fans; however, in many places it lies on relatively level local alluvial deposits left by minor streams in the upper parts of valleys (pl. 4, *A*). In the upper valleys it is distinguished from the Chehalis soils by having a more yellowish color, a mottled subsoil, and parent material derived predominantly from sandstone and shale. Its profile is more youthful than that of the Grande Ronde soils.

The surface soil, extending to a depth of 8 or 10 inches, is light brownish-gray or pale-brown granular and friable loam containing a small quantity of gritty loam slightly mottled with yellow and rust brown. This layer grades into a subsoil of light yellowish-brown silt loam or gritty loam, which rubs smooth and is moderately to strongly mottled with rust brown, yellow, and faint blue or light gray. The mottling gives a variegated appearance. At depths of 30 to 40 inches this subsoil rests upon a substratum of variegated yellow-and-brown mottled sandy loam or highly weathered transported sandstone and sandy shale. The substratum is firm in place but easily breaks down when removed. Some small mica particles occur in sand of the substratum.

Use and management.—All of Galvin loam, very gently sloping, has been logged, but probably less than half is being farmed. Much of the uncleared land is grazed. Crops, yields, and cultural practices are similar to those on Galvin silty clay loam, very gently sloping, although the soil is more easily drained and less subject to saturation during winter. Crops also mature earlier than on the heavier textured Galvin soils.

Galvin silt loam, very gently sloping (GB).—Like Galvin silty clay loam, very gently sloping, this phase is widely distributed in the western part of the county. It has a more friable silt loam surface soil and slightly less compact subsoil. Otherwise it resembles Galvin silty clay loam, very gently sloping, in profile, drainage, and other characteristics, including crops, yields, and farm practices.

Galvin silty clay loam, very gently sloping (GD).—Areas of this soil are widely distributed throughout the western part of the county. They occupy very gently sloping imperfectly drained fans and small valley fillings at the mouths of small canyons and intermittent streams where alluvial material has been deposited over stream-bottom soils. The soil is closely associated with the Melbourne soils, from which its parent material is largely derived. Surface drainage is enhanced by the slope (2 to 5 percent). Seepage and subdrainage waters from the hills and canyons above keep the subsoil fairly well saturated and

result in scattered seep areas and variable drainage. Although the aggregate area is relatively large, individual areas are usually small.

The surface soil extends to a depth of 8 or 10 inches and consists of grayish-brown or light grayish-brown granular and friable silty clay loam showing a moderate amount of yellow and rust-brown staining. This layer grades into yellowish-brown firm silt loam or silty clay loam, which contains a small quantity of weathered gritty material, breaks into irregular fragments, and shows moderate to strong mottling with light gray, rust brown, and yellowish brown. Between 20 and 24 inches this mottled layer becomes more highly stained and mottled, slightly more firm, and contains a small quantity of weathered micaceous sandstone. Yellow and rust-brown mottlings and light-gray blotches give it a variegated color. At depths of 3 to 4 feet this layer grades into highly mottled light-gray relatively compact but crumbly yellowish-brown clay that continues for several feet. In the substratum and occasionally in the subsoil some fine sand is in places mixed with the clay.

Use and management.—Native timber on Galvin clay loam, very gently sloping consists largely of mixed conifers and deciduous trees, usually cedar, ash, maple, and alder. Brush, shrubs, and some scattered wild rose, spiraea, and sedges form a heavy undercover. Most of the land has been logged, and that which has not been cleared supports a heavy second-growth cover similar to the original. A relatively large acreage is cleared for farming or partly cleared for stump pasture. Many home sites are located on this soil because it has better surface drainage than the adjacent lowlands and is free from winter floods.

Cultivated areas are usually farmed with associated areas of Chehalis, Wapato, or Reed soils. Crops are similar. Drainage is usually established by open ditches cut across the upper parts of the fans to divert excess surface and seepage water. The common crops are hay, small grains, and pasture mixtures. Oat hay yields 1½ to 3 tons an acre; oat and vetch hay, approximately 3 to 6 tons; and clover-and-grass mixture, 3 to 4 tons. The grass hays are usually pastured after the first cutting. Alsike clover is commonly grown on the wetter land, although red clover is also grown. Pasture mixtures recommended by the Washington State College Extension Service include Italian and English ryegrasses, orchard grass, Kentucky bluegrass, and common white, red, and alsike clovers (*7*). A mixture of these plants is suitable for stump pasture lands. Fruit trees and perennials are grown to a minor extent in home orchards, but the soil is not well suited to them.

When cultivated the soil soon is depleted of organic matter and nitrogen, which must be supplied for satisfactory results. Barnyard manure is the commonly used fertilizer, although some farmers apply phosphate fertilizer with the manure to improve pasture and crop yields.

Galvin silty clay loam, gently sloping (Gc).—Slightly stronger slopes (5 to 10 percent) distinguish this soil from the very gently sloping Galvin silty clay loam. The texture of the surface soil is more variable, some of the areas having loam and others a silt loam

texture. The soil is used principally for grazing or stump pasture; very little is cultivated.

Glenoma silt loam (Gf).—Gently sloping basin land in the central part of Rainy Valley is occupied by this soil, which has developed in the area of pumice fall. Fragments of pumice are scattered through the surface soil and occur in layers, or strata, in the subsoil. The parent material is derived principally from mixed basic and acidic igneous terrace sediments laid down by the Cowlitz River but reworked and added to by local stream action. The pumice evidently lies practically where it fell and has since received overwashes of alluvial materials that have been carried down into and mixed with the mass of coarse fragments.

The surface soil, 10 to 14 inches deep, is brown or grayish-brown granular and friable silt loam containing many yellowish pumice fragments varying from the size of coarse sand grains to a maximum of 1 to 1½ inches in diameter. Underlying this layer is an 8- to 12-inch stratum of yellowish-brown pumice fragments mixed with sufficient brown soil material to give it consistence. The pumice is relatively highly weathered and stained with rust brown and yellow. Below the pumice layer and continuing to a depth of 32 to 38 inches the subsoil is slightly compacted yellowish-brown clay loam or silty clay loam containing only a few scattered pumice fragments. This clay subsoil layer rests on smooth, dull yellowish-brown or brown silty clay or silty clay loam, slightly compact but permeable, that contains small irregular particles coated with colloids and stained with rust brown. Some bluish mottling occurs along the root channels below 3 feet; this mottling increases with depth until the water table is reached, generally at about 12 feet.

Use and management.—Glenoma silt loam developed under a heavy coniferous cover made up of fir, hemlock, and cedar, some maples and alders, and a heavy undercover of brush and shrubs. All of the land has been logged; that not cleared has a cover similar to the original.

The soil occupies about 1½ square miles, of which less than 400 acres are farmed. Surface drainage is well established, and internal drainage is sufficient to permit its use for crops. The principal enterprise is dairying, and the dominant crops are hay and pasture. Red and alsike clovers mixed with ryegrass and timothy are commonly grown for hay and pasture. The first crop is usually cut for hay; the second, often pastured. Yields are 2½ to 4 tons of hay. Oat or oat-and-vetch hay is also grown and gives good yields. Pasture stands commonly consist of mixtures of timothy and red and alsike clovers, but Kentucky bluegrass and orchard grass are used in some. The soil is fertile and only slightly acid. Organic matter and nitrogen are supplied by additions of barnyard manure and by the clover in the hay and pasture mixtures. The soil is similar to the Olequa soils, and crops and practices closely correspond.

Glenoma loam (Ge).—In origin, development, and occurrence this soil is similar to Glenoma silt loam, but it appears that since the pumice fell it has been less affected by local stream action. The surface soil is therefore much higher in pumice. The soil occupies about 2 square miles and occurs principally in an intermediate position between Glenoma silt loam and Cispus pumicy sandy loam soils.

The surface soil, 8 to 14 inches deep, consists of loose, friable, and granular grayish-brown gritty loam highly impregnated with yellowish pumice fragments. This layer grades into lighter colored material slightly higher in pumice, which extends to about 25 inches before it is replaced by brown or slightly yellowish-brown firm silty clay loam containing a small quantity of scattered pumice. At depths of 2½ to 3 feet is brown or slightly yellowish-brown clay loam.

Root channels in this soil are colored with yellow, rust-brown, and slightly bluish mottlings that increase in frequency with depth. In a few areas, principally those in the west end of Rainy Valley, gravel is scattered through the soil. Relative quantities of pumice throughout the solum commonly vary.

Use and management.—This soil corresponds closely to Glenoma silt loam in agricultural value. Only a small percentage is cleared and cultivated; most of the area has a dense cover of alder, maple, brush, and second-growth fir. Some of the land has been partly cleared and is being used for stump pasture. Crops and cultural practices are similar to those on Glenoma silt loam, but yields and carrying capacity are lower, the water-holding capacity is lower, and the soil in general is less desirable.

Grande Ronde silty clay loam, shot phase (GH).—This inextensive soil occupies undulating to very gently rolling or slightly hummocky terrace positions. It occurs on terraces in the floors of small valleys in the western part of the county where the annual precipitation is high. Surface drainage is not restricted, but during the wet season the water table is within a few feet of the surface. The phase is derived almost entirely from sandstone and shale materials and frequently contains small shale fragments.

The 8- to 12-inch surface soil consists of brown friable granular and shotty silty clay loam. The upper subsoil, to an average depth of 24 inches, is light yellowish-brown slightly compact or firm silty clay loam, almost free of shot and faintly stained with yellow and purple. The lower subsoil, extending to 36 or 40 inches, is light yellowish-brown gritty clay loam, less firm than that above, and slightly more stained with yellow. This lower subsoil grades into strong yellowish-brown highly weathered transported materials derived from sandstone and shale. The transported material has a firm consistence and light-gray, purple, and yellow stains. It contains in some places small fragments of highly weathered basalt or purplish concretions but is dominantly of sedimentary origin. The subsoil and substratum both contain a small quantity of shiny micaceous sand.

The quantity of shot in the surface soil and the degree of mottling or staining in the subsoil vary within short distances because drainage and aeration differ in the slight rises and swales. The soil appears to be more maturely developed than the Olequa soils and less fertile.

Use and management.—About four-fifths of Grande Ronde silty clay loam, shot phase, occurs in the structural valley north and south of Wildwood. Nearly all of the land has been logged and is now covered with many large stumps, but it is slowly restocking to brush and timber. Where grass and clover can be seeded and maintained, these stump lands afford grazing. Only a small area is cultivated.

Grande Ronde silt loam, shot phase (GG).—This soil occurs mostly in small valleys in the western part of the county. It has a more friable coarser-textured surface soil than Grande Ronde silty clay loam, shot phase, with which it is associated, and is slightly easier to till. Only a small acreage is cultivated.

Greenwater loamy sand (GL).—In greater part the well-drained more recent low terraces in the upper valley of the Nisqually River are occupied by this soil, which, to lesser extent, also occurs along the Cowlitz River near Kosmos. The material for this soil apparently is made up of pumice-influenced glacial outwash deposits consisting of gray and dark-gray sand derived from basic rocks of basalt and andesite and washed from the flanks of Mount Rainier. In a few places the material is gravelly or stony, and erratic boulders indicate transportation by floating glacial ice.

In virgin areas the surface soil is covered by a dark-brown organic mat 1 or 2 inches deep. In many places a thin layer of podzolic flour lies just under the organic mat. The surface soil, extending to a depth of 10 to 12 inches, is loose yellowish-brown loamy sand with a pepper-and-salt appearance caused by dark and light-gray sand grains and a yellowish fine pumice. This layer is underlain by 12 to 20 inches of lighter colored coarse and angular loamy sand that contains a moderate quantity of fine pumice. In this part rust staining and iron cementation in places indicate a faint ortstein development. Underlying the layer of loamy sand is the substratum of slightly compacted yellowish-brown, gray, and dark-gray sand. Below a depth of 2½ to 3½ feet the substratum becomes more compact and olive gray and has a pepper-and-salt appearance.

Use and management.—Greenwater loamy sand is very droughty and of little value for cultivation. Considering the low water-holding capacity of the soil and large conveyance loss, it probably would not be worth irrigating. All of the land has been logged and is now being restocked by second-growth timber, dominantly Douglas-fir. Very little has been cleared. Scattered white pine and white fir are further evidence of the soil's droughtiness.

Greenwater sandy loam (GM).—This soil is located on lower terraces with Greenwater loamy sand. It is derived from materials similar to those of that soil, but appears to have had a more recent deposit of fine sediments that give its surface soil a peculiar mixed sand-and-silt texture and a light brownish-gray to light grayish-brown color. Underlying the surface soil at varying depths between 10 and 24 inches is gray, yellowish-brown, and dark-gray variegated loamy sand similar to that in the subsoil and substratum of Greenwater loamy sand. The olive-gray pepper-and-salt coarse sand is 1 to 2 feet deeper in this soil than in Greenwater loamy sand.

Use and management.—Only a very small acreage of Greenwater sandy loam has been cleared for cultivation. The soil is only a little less droughty than Greenwater loamy sand, and yields are relatively low.

Greenwater fine sand (GK).—This soil occurs in association with the Siler soils and other members of its own series. In many areas it occupies slightly lower positions than Greenwater loamy sand and

Greenwater sandy loam. Some areas are subject to overflow during periods of above-normal precipitation.

The profile is irregular but is made up principally of strata of pumice, brownish-gray loamy sand or fine sand, dark and light-gray pepper-and-salt coarse sand, and pale yellowish-brown loamy fine sand. These materials occur in almost any order; however, they appear principally in the order named or with the first and second layers interchanged. The layer of dark-colored coarse sand is not always present. The pumice consists of yellowish-white fragments 1 to 4 millimeters in diameter. From Randle progressively northeastward toward Packwood, the pumice becomes gradually finer in size, but it is not appreciably different in character.

Use and management.—Greenwater fine sand is loose, porous, and very droughty. Only a small acreage is cleared, and areas cleared are used principally for grazing or permanent pasture. The carrying capacity is low, and grazing is afforded only for a short time in spring and late in fall.

The native vegetation consists largely of Douglas-fir and hemlock, scattered areas of alder and maple, and a relatively heavy undercover of vine maple, salal, bracken, and other shrubs and brush. Most of the area has been logged and is growing up in a second-growth cover of the types in the original stand.

Klaber-Olequa silty clay loams (KA).—In this complex Klaber and Olequa silty clay loams are mapped together because gradations between the two are so gradual and the areas of each are so intricately associated that separation on the map was either impracticable or impossible. The complex occurs principally on slight rises or along low narrow ridges where drainage conditions are improved. Probably 50 percent of the complex consists of Klaber silty clay loam, about 10 percent or less of Olequa silty clay loam, about 10 percent of gradations between the two, and the rest of Dryad silty clay loam. Drainage is better established, and this complex is therefore better suited to winter grains and perennial crops than the associated Klaber silty clay loam. In kinds of crops, management, and yields this complex corresponds to Klaber and Dryad silty clay loams.

Klaber silty clay loam (KF).—This soil is widely distributed throughout the county on nearly level relatively poorly drained areas on river terraces, usually in association with the Olequa soils. It occupies a lower more poorly drained position than the soils of the Dryad series, has developed a grayer surface soil, and has a more compact subsoil.

The surface soil is light brownish-gray or light olive-gray granular silty clay loam, the irregular-shaped granules of which have surfaces slightly stained with brown and yellow. This material is fairly friable under optimum moisture conditions. At 10 or 12 inches, however, it is slightly heavier and compact and has more brown, rust-brown, and yellow-brown mottlings. At depths of 18 to 26 inches there is a gradual transition to a slightly compact yellowish-gray silty clay, highly mottled with rust brown and yellow. This silty clay contains many root channels that make it almost vesicular, and its irregular soil fragments have a strong colloidal coating. The lower

A, Road cut in Cispus pumicy sandy loam, gently undulating. Some soil development has occurred, for the surface soil is much darker colored and somewhat finer textured than the subsoil.

B, Virgin timber, principally Douglas-fir, on Cispus pumicy sandy loam, gently undulating. Pumice deposit is about 3 feet deep. Roots of trees and of the brush understory penetrate the pumice.

A, Small valley in western part of Lewis County. Oats on Galvin loam, very gently sloping, in foreground; cut hay and pasture on Wapato silty clay loam in center; and Melbourne silty clay loam soils on hills in background.
B, Kopiah silt loam in the depression is used for pasture, the adjacent undulating areas of Salkum silty clay loam for grain and forest.

subsoil, at depths of 32 to 42 inches, consists of yellowish-gray silty clay fairly highly mottled and stained with rust brown, dark brown, yellow, and a little purple. This layer is very smooth and firm but permeable to roots and moisture. A few well-rounded gravelstones, dominantly of basic igneous origin, and minor stratified sand deposits occur in places.

The texture of the surface soil is usually between a heavy silt loam and a light silty clay loam. On the south side of Klickitat Prairie the subsoil is much lighter gray and more compact than typical; whereas the area about 1 mile southeast of Mossyrock has a darker gray surface soil and only a slightly mottled relatively compact slate-gray silty clay subsoil. An area of 200 to 300 acres that occurs about 1 mile west of Meskill has a large percentage of fine sand in the surface soil and subsoil.

Use and management.—The native timber of fir, cedar, and hemlock has largely been cut, and areas that have not been cleared support a heavy second growth of timber and brush. The fir, cedar, and hemlock are associated with maple, cottonwood, willow, alder, and Oregon ash, a few aspen, and a heavy undercover of vine maple, dogwood, wild rose, spiraea, blackberry, fern, salal, and a few sedges on the wetter areas. Along the upper part of Salmon Creek swordfern grows profusely under virgin timber.

In its natural state this soil is poorly drained and wet until late in spring. Drainage is not difficult in most places and is usually accomplished by open ditches or, to lesser extent, by tiling. Areas adequately drained can be successfully cropped. Under cultivation the soil becomes depleted of organic matter and nitrogen and must receive phosphate fertilizers as well as manure or other forms of nitrogen for best results. Other fertilizers or lime are not used and do not seem to benefit the soil enough to warrant their cost.

The crops are principally hay, small grains, and pasture for dairy herds. Farming practices and management are similar to those on Kopiah silt loam, but yields average higher. A few of the more permanently wet areas are sown to Reed canarygrass, which affords high yields of hay and produces pasture of high carrying capacity.

Klaber silty clay loam, gravelly subsoil (KG).—This soil is associated with the Winston soils and to a very minor extent with the Onalaska. It usually occupies low poorly drained areas on stream terraces and is characterized by a shallow surface soil over a very gravelly subsoil. It is fairly widely distributed but not extensive in acreage.

In a typical profile there is a thin layer of organic matter over 12 to 14 inches of light brownish-gray or brownish-gray silty clay loam or light clay, which is fairly granular and friable. Some slight yellowish mottling occurs all the way to the surface, and rounded gravelstones are usually scattered over the surface and through the layer. The surface soil grades into highly mottled and stained silty clay or clay subsoil, which is light gray variegated with yellow, orange, and rust brown. The subsoil is compact and contains some gravel. At varying depths between 10 and 36 inches the subsoil rests abruptly upon a very gravelly substratum containing sufficient interstitial clay

to be cohesive and fairly compact. This substratum is fairly highly mottled with rust brown and yellow, and the gravel is highly stained.

The gravel content throughout the surface soil is variable over short distances but seldom impedes cultivation. In most places the surface soil is relatively free of gravel. A few areas have a sandy clay subsoil and a sand-and-gravel substrata. In spots within some of the large areas the soil is fairly shallow, the substratum being within 12 to 16 inches of the surface.

Use and management.—Surface drainage of Klaber silty clay loam, gravelly subsoil, is restricted. Internal drainage is impeded by a high water table and by the compact clay and gravel substratum; therefore, the soil must be drained before it can be cultivated. Drainage is made difficult by the shallowness of the surface layer and the very gravelly substratum; hence, only a few areas have been cleared and drained. Crops for the most part are restricted to hay and pasture, chiefly of alsike clover, rye, and timothy mixtures, which are usually cut for hay rather than pastured. Permanently wet spots are occasionally seeded to Reed canarygrass.

Most of this soil has been logged and is now heavily covered by a second growth of mixed coniferous and deciduous trees and a heavy undercover of brush and shrubs.

Klaber silt loam, gravelly subsoil (KE).—This soil occurs in several widely scattered areas in association with Klaber silty clay loam, gravelly subsoil, which it resembles in most characteristics except its lighter textured more friable surface soil. Its surface soil—a relatively friable light grayish-brown silt loam—grades into a highly mottled and stained slightly compact silty clay loam subsoil. The subsoil in turn rests on a gravelly substratum similar to that of Klaber silty clay loam, gravelly subsoil. Native cover crops and land conditions are similar to those on Klaber silty clay loam, gravelly subsoil. Only a very small part of this soil has been cleared for cultivation.

Kopiah-Onalaska silty clay loams (KB).—This complex consists of areas of Kopiah and Onalaska soils so intricately mixed that their separation is either impracticable or impossible at the scale used in mapping. The complex occurs only where slight changes in relief are accompanied by gradual and indistinct variations in drainage. Kopiah silty clay loam occurs on the low-lying land; Onalaska silty clay loam is on the rises and small knolls. Soils intermediate in character between the two are on the intervening land.

Use and management.—Only a small part of Kopiah-Onalaska silty clay loams is cultivated. Most of the land has been logged and is covered with second-growth timber and brush. The cultivated areas produce hay, pasture, and some grain. Yields and farm practices correspond to those on the two soil types making up the complex. Stump land is profitably used for grazing, and natural grasses are usually augmented by light seedings of common clover and grass mixtures. Brush clearing is helpful in keeping undesirable vegetation at a minimum.

Kopiah-Salkum complex, sloping (KC).—This complex occurs on slopes of 6 to 15 percent where small areas of seepage soils similar to

those of Kopiah silt loam are so intricately mixed with areas of Salkum silty clay loam that separation on the map is either impossible or impracticable. Salkum silty clay loam occupies the higher areas and small ridges; Kopiah silt loam, the numerous basins and seep spots. The Kopiah soil in these locations is much shallower than it normally is and often contains considerable gravel.

Use and management.—Nearly all of Kopiah-Salkum complex, sloping, has been logged and is slowly restocking with second-growth timber and brush. Areas slow in restocking can be seeded to the common grass-and-clover mixtures and used for grazing. Stands are difficult to obtain unless seeding is done immediately following a burn or unless some light tillage operations follow the seeding. Natural vegetation is partly held in check by grazing livestock, but additional clearing and maintenance are usually necessary.

Kopiah silt loam (KD).—Low, nearly level imperfectly drained areas in the Salkum plain are occupied by this soil, which developed from the same ancient weathered clay-and-gravel matrix as soils of the Salkum series. In the drainage catena formed by soils of the Salkum, Scamman, and Lacamas series—ranging from well drained to poorly drained in the order named—Kopiah silt loam occurs between soils of the Scamman and Lacamas series.

The surface soil of Kopiah silt loam consists of 10 to 12 inches of light brownish-gray moderately acid friable silt loam. In the virgin state the top 2 or 3 inches are much darker, because they contain more organic matter. Faint-yellow and rust-brown mottling frequently occurs all the way to the surface. The upper subsoil is light-gray, yellowish-gray, or nearly white silt loam or silty clay loam highly mottled with rust brown and yellow and splotched with lighter gray. This layer extends to a depth of 20 to 26 inches, where it grades into the lower subsoil of pale yellowish-gray clay or gritty clay. The clay subsoil is fairly heavy and stiff but not so dense or so compact as the subsoil of Lacamas soils. It has a slight blocky structure that breaks into smaller, irregular, highly stained and colloid-coated units. Many small root channels are also highly stained. At varying depths between 36 and 48 inches the lower subsoil rests on highly mottled and stained disintegrating gravel and clay. This material is similar to that underlying the Salkum series but is much grayer and more highly stained because of its greater saturation.

Use and management.—Kopiah silt loam is widely distributed in the general areas of the Salkum soils. It occurs most commonly as fairly narrow bodies along intermittent drainage channels but is also on nearly level depressional areas intermediate in drainage between soils of the Salkum and the Lacamas series (pl. 4, *B*). The soil is saturated and marshy during winter and early spring and must be drained before it can be successfully farmed. When adequately drained (the usual method is by open ditch drains) and properly managed, the soil is fairly productive of grain, hay, and pasture. Although farms consisting wholly of this soil are not desirable, small areas of it included with the Salkum soils can be used satisfactorily for pasture and hay.

Probably less than half of this soil has been cleared or partly cleared and is in use. Nearly all the rest has been logged and is supporting a heavy growth of mixed conifers, deciduous trees, and brush. Cedar,

hemlock, fir, alder, maple, ash, willow, and, in a few places, quaking aspen and Oregon white oak are the common trees on these wetter areas. Vine maple, wild rose, salal, spiraea, dogwood, and scattered sedges form a heavy undercover. Logged-off areas are soon heavily covered and must be partly cleared and carefully maintained even when used for stump pasture.

Because the soil becomes oversaturated during winter, nearly all the grain is planted in spring. Under favorable moisture conditions yields are high but are less assured than on the better drained soils. A mixture of oats and alsike clover yields 2½ to 4 tons of hay an acre. Mixtures of clover, timothy, and ryegrass are also commonly used for hay and pasture and give similar yields. The soil is usually too wet for red clover, but it produces a good stand of alsike. A pasture mixture recommended by the State Extension Service (7) for poorly drained land is made up of English and Italian ryegrasses, orchard grass, Kentucky bluegrass, and common white, alsike, and red clovers.

Stump land that has been burned over should be seeded, otherwise stands are difficult to obtain because of the competing vegetation. Bentgrass and timothy, as well as the mixtures previously mentioned, are commonly seeded on stump land. In most places pasturing can be started early in May and continued until November.

Cultivated areas soon become deficient in organic matter and nitrogen and should receive manure and crop residues or be planted to rotations containing legumes if yields are to be satisfactory. Crops respond well to 250 to 300 pounds of superphosphate or its equivalent added with manure or some commercial nitrogen fertilizer. Other fertilizers or amendments have not proved particularly beneficial.

Kosmos clay loam (KH).—This soil occurs in low basins and is confined to Rainy Valley. It has developed in the area of pumice fall and contains pumice fragments in layers or pockets or scattered throughout the profile. It is associated with the Glenoma soils and has developed from parent materials of similar origin, but under impaired drainage.

The surface soil is dark brownish-gray clay loam containing scattered particles of yellowish pumice similar to those in the Cispus soils. This material forms large irregular clods that, in turn, break into small angular crumbs; therefore water is readily absorbed. Below 6 or 10 inches the soil becomes slightly stained with darker material. At depths of 18 to 24 inches there is commonly a 8- or 10-inch layer of brownish-gray clay containing a large quantity of pumice that has become whitened and softened from weathering and gives a whitish appearance to the soil. The pumicy layer is more or less mottled with rust-brown and dark organic staining and in places shows bluish reduction colors. It grades into brownish-gray or slightly bluish-gray stiff and moderately compact clay having bluish and rust-brown mottling. This mottling is of varying intensity and increases with depth to the water table at 4 to 12 feet. The pumice content of this Kosmos soil is variable but in many places is about the same throughout the upper part.

Use and management.—Kosmos clay loam has developed under a forest cover of fir, hemlock, and cedar and numerous deciduous trees, shrubs, and brush. Areas not cleared support a heavy second-growth

and a ground cover of sedges, spiraea, wild rose, and skunkcabbage. Where drained the soil can be used for cultivated crops. It is usually drained by open ditches, although some closely spaced tile drains are used. The removal of excess surface water is the most important consideration. About half of the land has been cleared, and when it is adequately drained it is good for hay and pasture. Mixtures for pasture and hay commonly include meadow grass, red, white, and alsike clovers, and Italian ryegrass. The first crop is usually cut for hay, and the fields are then pastured. Some oats are grown for hay, seeded as a nurse crop for clover, or seeded with vetch. The soil is fertile. Yields compare favorably with those obtained on the better soils of the county.

Lacamas silt loam (La).—Large nearly level depressional areas with impaired surface drainage are occupied by this soil. Associated with it are Salkum silty clay loam and Kopiah silt loam. The soils constitute a catena, or group, that has developed from similar parent materials but under different drainage conditions. This soil and Lacamas silty clay loam are the more poorly drained members of the catena and have developed a very dense clay subsoil.

The surface soil, extending to a depth of 10 to 16 inches, consists of light olive-gray smooth friable and softly granular silt loam. In virgin conditions, where the organic content is greater, its upper inch or two is darker, but where cultivated it has very light-gray or whitish appearance. The lower 2 or 3 inches of the surface layer are slightly mottled with yellow and rust brown.

The surface layer rests abruptly on a 6-or 8-inch upper subsoil layer of light-gray dense and compact clay that has a faint columnar structure. Degraded whitish ashy material forms an irregular cover in the tops of the columns and forms a thin coating along cleavage planes and root channels. Gradually replacing the light-gray clay is a compact and dense yellowish-gray or very light-gray clay layer that has a slightly blocky structure. In this layer degraded ashy material occurs in stringers or as fingers along the cleavage lines and root channels. At 28 to 36 inches is pale-olive dense waxy clay, less compact than that in the layer above and without definite structure. Some slight rust-brown and dark-brown staining occurs along the few root channels. This lower subsoil is 5 feet or more deep and rests on the highly disintegrated gravel and clay typical of Salkum parent material.

Use and management.—Surface and internal drainage of Lacamas silt loam are both impaired; the soil is saturated during winter and early spring. Some form of drainage is necessary before this soil can be used for cultivated crops. Drainage is difficult because of the dense clay subsoil and substratum. The use of tile is not particularly effective; consequently, nearly all of the areas are drained with open ditches supplemented by shallow lateral drains left after plowing. The principal value of these ditches is to carry off excess surface water.

The native vegetation is made up largely of mixed deciduous trees, brush, and shrubs, but shallow-rooted firs, cedars, and lodgepole pine of poor quality grow in some areas. The deciduous trees are largely willow, ash, maple, a few cottonwoods, and some quaking aspen and Oregon white oak. The heavy undergrowth consists of shrubs, brush, and other plants, including vine maple, spiraea, wild rose, swordfern,

salal, and sedges. Nearly all of this soil has been logged of its marketable timber, but probably less than one-fourth has been cleared sufficiently for cultivated crops.

The soil is limited in use; the principal crops are hay and pasture. Clover, ryegrass, and timothy are the most popular hay crops and yield 2 to 3½ tons an acre. Alsike and common white clovers are used, principally in place of red clover. The first crop is usually cut for hay, and the second is pastured. Permanently wet areas are often seeded to Reed canarygrass. Oats and alsike clover sown together are a common hay crop and yield 3 to 4 tons an acre. When harvested for grain, oats yield 40 to 50 bushels an acre. Yields are often much lower and occasionally much higher, depending principally on moisture conditions. Only the spring varieties of oats are used, for winter oats are often drowned or forced out by freezing winter weather or rot as a result of excessive spring rain.

Permanent pastures are seeded to clover, ryegrass, and timothy, as is also the cut-over land. These cut-over areas, if put in bentgrass or timothy, may afford good supplementary pasture until December. The carrying capacity of cut-over land depends largely on the number of stumps and brush. Usually between 3 and 5 acres are needed for each head of cattle. This poorly drained soil is not suited to other crops, and farm units consisting wholly of such soil are therefore not particularly desirable.

The principal fertilizer is manure. Occasionally, 300 pounds of superphosphate an acre, in addition to the manure, is applied to clover fields. Crops respond best to phosphate and nitrogen fertilizers; other fertilizers and lime have not proved particularly beneficial. Even manure is difficult to apply in some places because the soil is so saturated with moisture during winter.

Lacamas silty clay loam (Lb).—This soil is as extensive as Lacamas silt loam and is widely distributed throughout the nearly level depressional areas of the Salkum plain.

The surface soil is friable and slightly granular light olive-gray silty clay loam. At 8 or 10 inches it grades into gray or yellowish-gray mottled and stained silty clay loam, which rests at about 15 to 18 inches on a 3- or 4-inch light-gray dense clay layer having a slight columnar structure. The structural units of the dense clay are coated with degraded ashy material. Below this light-gray zone and continuing to a depth of 32 to 38 inches the subsoil is darker colored and blocky, has whitish ashy material in streaks along the cleavage lines, and shows much colloidal coating on the small clay fragments. The substratum of yellowish-gray cheesy stiff clay occurs at 32 to 38 inches and continues to 5 feet or more, where it grades into highly weathered and stained material similar to the parent material of the Salkum soils.

Use and management.—In use and management practices Lacamas silty clay loam is fairly similar to Lacamas silt loam. The surface soil is slightly heavier, usually darker, and on the average more poorly drained and swampy. Drainage is necessary before the soil can be used. Probably one-fourth of the land is cultivated. It is used mostly for pasture and hay. Yields are similar to those on Lacamas silt loam.

Lynden fine sandy loam (Lc).—This inextensive soil, developed from gravel-free glacial outwash sand, is closely associated with Nisqually soils but has developed under coniferous forest rather than prairie grasses.

Under a 1- to 2-inch organic surface mat the surface soil is rich-brown or slightly reddish-brown mellow fine sandy loam that contains a few fine shotlike pellets. At 18 to 20 inches this layer grades into yellowish-brown fine sandy loam or loamy fine sand, massive in structure but easily broken to single grains. Between 30 to 36 inches this massive layer rests on a gray or grayish-brown, loose, porous, pepper-and-salt sand substratum that continues for several feet.

Use and management.—Most of Lynden fine sandy loam occurs within the city limits of Centralia; consequently its principal agricultural use is for gardens. A small acreage is in hay, small grains, truck crops, and pasture. The soil is productive under favorable moisture conditions.

Made land (Ma).—This land type consists of areas that have been made artificially from soil or miscellaneous materials. The total area is small and includes principally mine dumps or areas once occupied by lumber mills. It has no agricultural value.

Melbourne-Meskill silty clay loams (Mb).—This complex consists of Melbourne and Meskill silty clay loams so intricately mixed they cannot be shown separately on the map. It is not known whether the imperfect drainage of the soils in this complex is caused by hydrostatic pressure from underneath or by some underlying materials that restrict subdrainage. Both undoubtedly play a part, either separately or together. In the valleys, the streams have in places cut into a very compacted and cemented sandstone that probably underlies most of the area. Subdrainage waters from the higher mountains probably stay above this sandstone layer and, on reaching this general area, are forced to the surface. This would keep this complex saturated for long periods of time and account for the saturation of nearly all the terraces and bottoms south of the Cowlitz River in the general area.

Areas of the complex are variable and change within very short distances. Soil similar to Melbourne silty clay loam occurs in the well-drained positions, and soil similar to Meskill silty clay loam in those poorly drained. Gradations in drainage between well drained and poorly drained result in many variations in the soil profiles, but all gradations between the typical soils of the two series have fundamental characteristics common to both.

Use and management.—The virgin cover of Melbourne-Meskill silty clay loams consists of Douglas-fir, a high percentage of Western redcedar, and some hemlock. The undercover is thicker than on the better drained upland soils and contains many swordferns. Probably more than half of the area has been logged and is slowly restocking to second-growth trees similar to the original types. The soils do not absorb water rapidly, but erosion is held in check by the luxuriant cover. This land is best suited to forest, but parts of it could be used for grazing. Improvement of moisture conditions would permit a better grass cover and tend to relieve droughtiness late in summer. Grass mixtures should be seeded and carefully maintained, and exces-

sive underbrush controlled. Do not overgraze the pasture, as close grazing tends to eliminate the more favorable grasses and clovers and result in accelerated erosion.

Melbourne silty clay loam, hilly (MD).—This soil developed from argillaceous sandstone and shale under forest cover. It occupies large areas of hill land—equal to about 5 or 6 townships—that range from 300 to 1,100 feet above sea level. Slopes range from 15 to 30 percent.

In virgin areas the surface is covered by a 1- to 2-inch partly decomposed dark-brown organic mat. Abruptly under this surface mat is medium to slightly acid brown or dark grayish-brown silty clay loam surface soil, 10 to 14 inches thick. When wet this layer is dark brown. It is very granular and friable and contains a large quantity of shotlike pellets. Beneath the surface layer is the upper subsoil. It is moderately acid yellowish-brown or light-brown silty clay loam, firm but friable and very granular, that contains a few soft shotlike concretions. At depths of about 20 to 24 inches, the upper subsoil grades into a slightly compact lower subsoil of light yellowish-brown silty clay that breaks into colloid-coated small irregular fragments. Between 3 and 4 feet the lower subsoil grades into the parent material—smooth silty decomposed shale and argillaceous sandstone stained with rust brown. The surfaces of the shale fragments are highly colloid-coated and stained with yellow and rust brown, whereas their centers are gray. This material grades at varying depths into less decomposed but strongly weathered fragmental shale.

An area of about ½ square mile north of Lincoln Creek next to the Thurston County line consisting of soil developed from much more consolidated sandstone is included with this soil.

Use and management.—Surface drainage of Melbourne silty clay loam, hilly, is well established, but internal drainage is moderate. Seep areas of the Meskill soil commonly occur on the lower slopes and along stream channels, and areas of Melbourne soil that are adjacent to the Meskill soil have grayer surface soil and subsoil. The depth to the underlying shale is not so variable as would be expected from the wide range in slope.

In the virgin areas the soil supported a heavy forest cover, but almost all the trees have now been logged and only a very small acreage is cleared and being cultivated. Severe burning after logging has particularly affected the reseeding of these soils, and large areas are not restocking to merchantable timber. Some work has been done by Federal and State agencies, but much more is necessary before some of these large denuded areas will again produce timber profitably.

To a small extent some of this soil has been used for cattle grazing. Native wild vetches and white clovers are fairly prominent, but the acreage needed for each head of stock is high. Forage crops compete unsuccessfully with other vegetation, and the land is largely taken over by vine maple, alder, hazelnut, bracken, salal, Oregon grape, fireweed, and other brush and shrubs. Fallen timber also makes the use of the land for forage crops difficult and interferes with grazing. Unless constantly kept free of brush, areas seeded to grass mixtures are soon overgrown with native vegetation. Repeated burning to insure better grazing would probably soon present a serious erosion problem on some of the steeper slopes and should be discouraged in most places.

Agriculture is limited principally by the unfavorable relief, which hinders the use of farm machinery. A few small areas are farmed in association with areas of more favorable relief (see plate 4, *A*). These sections are used mostly for hay and small grain but in some places for deciduous fruits and garden crops grown for home use. Clearing of slopes for clean cultivation is hazardous and may result in reduced returns to the farmer and in accelerated erosion. This soil should be kept in forest.

Melbourne silty clay loam, rolling (ME).—The rolling soil differs from the hilly phase principally in having smoother relief. It occupies rolling or sloping areas (6- to 15-percent slopes). Only a small part is cultivated. Most areas are relatively small and are associated with the steeper areas or occur as foot slopes along the small stream bottoms. They are farmed with the more fertile alluvial soils.

A few areas east of Centralia have a gray surface soil and a mottled gray and yellowish-brown waxy plastic subsoil that grades into partly weathered clayey shale at depths of 3 to 4 feet. This clayey shale is yellowish gray and highly stained with red, yellow, orange, and brown. In places it resembles the weathered parent material of the Salkum soils.

Use and management.—Melbourne silty clay loam, rolling, has less rapid surface runoff than Melbourne silty clay loam, hilly, and is consequently less susceptible to erosion. Internal drainage is slow but not restricted. The structure of both the surface soil and the subsoil makes it permeable to water, and its heavy texture makes it highly retentive of moisture for crop use. As on other upland soils, however, crops are damaged by lack of moisture late during the dry summers. On the lower more gently sloping areas moisture conditions are usually slightly more favorable than elsewhere.

The phase is used principally for the hay, small grains, and pasture. Small acreages are planted to strawberries and deciduous fruits, chiefly for local consumption. The soil is less fertile than the Olympic soils, and yields are usually lower. It responds to fertilization, and under proper management produces favorable yields. Green-manure crops and manure are the most important sources of organic matter and nitrogen. Applications of phosphorus are also beneficial. Fertilizing practices are similar to those used on the Olympic and Salkum soils.

Melbourne silty clay loam, steep and hilly (MF).—Rougher and steeper parts of the hilly areas in the western part of the county are occupied by this soil. It occurs in association with Melbourne silty clay loam, hilly, and as shown on the soil map, is distinctly a complex of hilly and steep slopes.

In characteristics this soil is the same as Melbourne silty clay loam, hilly, except the underlying weathered shale fragments are closer to the surface. Surface drainage is rapid, but erosion is not so severe because the soil has a heavy vegetative cover and a structure favorable to rapid water absorption. Overgrazing or clearing of these steeper slopes might result in accelerated and ultimately severe erosion.

Nearly all of this land has been logged and is slowly restocking. Severe burning after logging, as well as subsequent burns, has in many places reduced the seed supply and organic matter of the sur-

face soil to such an extent that the better timber trees, principally Douglas-fir, are only very slowly gaining a foothold. The rapid growth of ferns, shrubs, and brush holds erosion in check but also produces a keenly competitive cover that tends to impede further the restocking of fir trees.

Melbourne silty clay, hilly (Mc).—This soil developed from argillaceous sandstones and shale material. It occupies hilly relief similar to that of Melbourne silty clay loam, hilly, but it has a darker surface color, heavier textured surface soil and subsoil, and shallow depth to parent material. Internal drainage is more restricted than in Melbourne silty clay loam, hilly. The soil is only slowly permeable to roots and water. Where this soil is adjacent to Melbourne silty clay loam, hilly, gradations between the two are gradual and continue over a relatively broad front.

In virgin conditions the surface is covered by a 1- or 2-inch organic mat of partly decomposed forest litter. The surface soil below the mat is moderately acid dark grayish-brown granular and friable silty clay that dries to brownish gray. At depths of 10 to 14 inches lies the upper subsoil, brownish gray or dark brownish gray and granular but slightly compact. It is not so distinctly granular as the surface soil, and the granules are coarse and irregular in shape. A few shotlike pellets occur in the surface soil and a lesser number in the upper subsoil.

The upper subsoil continues to a depth of 18 or 24 inches, where it grades into a lower subsoil formed of dark yellowish-brown or brown clay interspersed with yellowish-brown shale particles. The lower subsoil, of coarse granular structure, is firm to slightly compact but permeable to roots and water. Flat yellowish-brown shale fragments are scattered throughout the lower and the upper subsoil.

The substratum, or parent material, is disintegrating fragmental shale and argillaceous sandstone. It occurs at a depth of 2 to 3 feet and is variegated with dark-brown clay and smooth, yellow shale fragments. The surfaces and fissures of the shale fragments are stained with yellow and rust brown and coated with colloids. The parent material extends down several feet without appreciable change.

Use and management.—Melbourne silty clay, hilly, originally had a forest cover of Douglas-fir and some few hemlocks and cedars. A large part of it is now covered with a second-growth stand of Douglas-fir.

Most of the soil is on steeply sloping hill land (10- to 20-percent slopes). A few small isolated areas with slopes of less than 15 percent are included. Only a few acres are now farmed or have been cleared, and these are restricted to home sites or small acreages of pasture land. The principal use is forest, and further clearing would be undesirable.

Meskill silt loam, sloping (Mh).—This soil occupies seep and depressional areas in association with the Melbourne soils. Slopes are less than 15 percent.

The surface soil, to a depth of 8 to 12 inches, is light-gray or light brownish-gray friable and softly granular silt loam. Underlying is

grayish-brown slightly compact silty clay loam mottled with rust brown and yellow. Between 16 and 20 inches this mottled material grades into light-gray tough clay stained with blue and yellow.

The upper subsoil contains some light-gray degraded podzolic flour. The lower subsoil tends to be prismatic or blocky, but its structure is usually less strongly developed than that of Meskill silty clay loam, sloping. The parent material, occurring at varying depths below 3 feet, is composed of highly weathered and stained clays originating from decomposing shale.

Use and management.—The total area of this soil is small, and only a small percentage is farmed. Commonly it occurs on the less swampy areas where drainage is less restricted than for Meskill silty clay loam, sloping. Farm management, crops, and yields are very similar to those on Meskill silty clay loam, sloping. The cover of moisture-loving plants is also similar.

Meskill silty clay loam, sloping (ML).—This soil developed from argillaceous sandstone and shale under restricted and poor drainage. Slopes are less than 15 percent, with slopes between 6 and 10 percent predominant. In many places this soil occupies concave slopes within associated areas of Melbourne soils—slopes where seepage keeps it saturated.

Under a 1- or 2-inch layer of partly decomposed forest litter the 10- or 12-inch layer of surface soil is light-gray or light brownish-gray friable and softly granular silty clay loam. Traces of yellow and rust-brown mottling occur in the lower 3 or 4 inches and, in a few areas, nearly to the surface. The surface soil grades into pale olive-gray stiff dense and compact clay. This clay is blocky or slightly prismatic, and the smaller fragments are coated with colloids and degraded ashy material. Streaks of ashy coating occur along root channels and cleavage planes. At depths of 24 to 36 inches the compact clay grades into a lower subsoil and substratum of olive-gray or greenish olive-gray clay. This olive-gray clay is less compact or dense than the clay in the layer above and is mottled and stained with yellow and rust brown. It has a slight tendency to form a blocky structure and to break into coarse irregular fragments, which are highly coated with colloids. At depths below 3 to 4 feet there is a gradual transition to highly stained disintegrating shale.

The profile is relatively variable; the blocky structure is not so well pronounced in some areas. In many places the subsoil is highly stained and mottled.

Use and management.—The common cover of Meskill silty clay loam, sloping, is willows, spiraea, carex, and water-tolerant grasses. The original natural cover consisted for the most part of conifers and a heavy undercover of deciduous shrubs and brush. The soil usually occupies fairly small areas, but its aggregate acreage is large.

Many areas have been cleared and farmed with the better drained Melbourne silty clay loam, hilly, and more fertile soils of the flood plains. This soil is only moderately fertile and best suited to summer grains, hay, and pasture. Yields are variable and dependent to large extent on moisture conditions. Late in summer the soil tends to bake and form a very hard crust and is hard to work. The content of nitrogen and organic matter is low. During wet weather in spring

nitrification is slow, decreasing the length of the optimum growing season. On the wetter areas reed canarygrass does well and is one of the better pasture grasses. The soil under average conditions is best suited to grass hay or pasture.

Meskill silty clay loam, moderately steep (Mk).—This soil is characterized by small moderately steep seepage slopes. It occurs within areas of Melbourne soils and is usually fairly wet until late in summer. Profile characteristics are similar to those for other Meskill soils. Relief is not favorable for agriculture. The areas are too small to be managed separately from the surrounding soils and are best suited to pasture or grazing or to forest.

Meskill-Melbourne silty clay loams (Mg).—This complex occupies rolling or gently rolling slopes. On the lowest slopes it is associated with Melbourne-Meskill silty clay loams. It has a higher percentage of Meskill silty clay loam than Melbourne silty clay loam, whereas in the Melbourne-Meskill silty clay loams complex, Melbourne soils predominate.

Only a small area of Meskill-Melbourne silty clay loams is farmed, principally to small grains, hay, and pasture crops. Yields are variable and depend to a large extent on moisture conditions. Farm practices and recommendations are similar to those for Meskill silty clay loam, sloping.

Mossyrock silt loam (Mm).—High terrace positions are occupied by this soil. It is associated with some areas of Cinebar soils and developed from similar silty material but under a grass-and-fern prairie vegetation. The plant cover is responsible for the very dark surface soil. The soil is slightly acid throughout. It has very gently undulating to nearly level relief, is readily permeable, and porous enough for adequate drainage.

The surface soil, to a depth of 3 to 4 inches, is very dark-brown or nearly black very friable silt loam, high in content of organic matter and grass roots. Underlying to depths of 12 to 16 inches is very dark-brown softly granular mellow and friable silt loam, also high in organic matter. This underlying layer is 6 to 8 inches thick and grades into the dark yellowish-brown mellow silt loam upper subsoil. The upper subsoil extends to a depth of 36 to 42 inches and rests upon a light yellowish-brown silt loam lower subsoil. This lower subsoil, firm in place but very mellow and permeable, extends to 8 feet or more, where it rests on compact sand and gravel similar to that underlying Winston soils.

Use and management.—Mossyrock silt loam occupies a prairie area where grass-and-fern vegetation has persisted despite the fact that climate and soil are favorable for forest trees. Because of its open prairie vegetation and high fertility, the soil was settled in early days and has been cropped continuously for many years. Potatoes and hops were among the early crops. Hops are no longer grown in this county for economic reasons, and infestations of the flea beetle have reduced the potato yield until the crop is no longer grown on a commercial scale. Some plantings of potatoes made after the middle of June yield 100 to 300 bushels, depending upon the available moisture supply. Original yields of 600 to 800 bushels were recorded.

The principal crops are hay, grain, pasture, and some corn for silage. The soil holds adequate moisture for late-maturing crops. Oats, oats and vetch, grasses, and clover-and-grass mixtures are the common hay crops. Oats yield 1 to 3 tons of hay or 60 to 70 bushels of grain. Oat- and vetch-hay produces 3½ to 4 tons; grass-and-clover hay, 2 to 4 tons. After the first hay crop is harvested the fields are usually pastured. Wheat produces 35 to 45 bushels.

The soil is fairly high in inherent fertility and only slightly acid; therefore it is suitable for a wide range of crops. As a result of continuous cropping over a long period of years, the active organic matter and available nitrogen content have been reduced. Additions of barnyard manure and crop residues or the use of clovers in hay and pasture crops will aid in maintaining supplies of nitrogen and organic matter at the level necessary for satisfactory crop production. An application of 250 to 300 pounds of superphosphate an acre brings good responses from the crop to which it is applied and has a residual effect beneficial to other crops that follow.

Nesika clay loam, seep phase (NA).—In association with other Nesika soils this phase occupies the lower margins of the alluvial fans where subdrainage is partly restricted. It is derived from materials similar to those of the other Nesika soils but contains few angular gravelstones and stones and has a heavier surface soil and mottled subsoil.

The surface soil is dark grayish-brown highly organic granular and friable clay loam. At depths ranging between 8 and 14 inches it grades to grayish or yellowish-brown clay loam that is slightly compact and moderately stained and mottled with rust brown and yellow. This mottling increases with depth, and the material becomes relatively sticky. A few angular gravelstones occur below 2 or 3 feet. Small seep spots of peat or muck are commonly scattered throughout the area.

Use and management.—Most of Nesika clay loam, seep phase, is covered by second-growth alder, willow, maple, vine maple, and other deciduous growth and fir, hemlock, and cedar. The luxuriant undergrowth consists of brush, shrubs, skunkcabbage, and sedges. Where cleared the soil produces excellent pasture and, when adequately drained, high yields of oats and hay. It is necessary to drain the seepy spots, otherwise farm machinery bogs down. The soil is gently sloping and usually easily drained by open ditches, box ditches, or tiles.

Nesika loam, very gently sloping (NE).—This phase occurs in the eastern part of the county on broad well-drained alluvial fans having slopes of 2 to 5 percent. It is derived from a mixture of parent materials that are predominantly of basic igneous origin.

Under a 1- or 2-inch organic mat in virgin areas, the surface soil is dark-brown or brown loam or silt loam 4 to 12 inches deep. This layer has a soft granular structure, is friable, and works to a good tilth. Its organic content is high, and commonly there is enough angular gritty material to give a gritty feel. A brown, slightly dark-brown, or dark yellowish-brown firm gritty loam subsoil replaces the surface soil gradually. At depths of 24 to 36 inches it rests upon the substratum. The substratum consists of angular and subangular gravel

and yellowish-brown interstitial soil material that is fairly loose but not exceedingly porous. The gravelstones are slightly stained with yellow and rust brown in the upper part.

Small angular and subangular gravelstones, principally of basic igneous origin, are scattered on the surface and, in increasing quantity with depth, throughout the soil. Pumice fragments occur only in a very few places and are not typical of the soil.

Use and management.—Nesika loam, very gently sloping, has developed under a coniferous forest cover containing scattered deciduous trees and a heavy undercover of shrubs and brush. All the land has been logged, and that not cleared, supports a heavy second-growth cover. Little of the land has been cleared for cultivation; the principal cultivated area is south of Morton.

The soil is fertile and fairly productive. Surface drainage is well established, and internal drainage moderate. Moisture adequate to mature crops is retained in all but exceptionally dry years. In the interior valleys the June rains are usually heavy, resulting in a shorter dry season. Also, spring frosts occur late, and crops are usually not planted until May or early in June.

The distance to market limits farming almost entirely to dairying, and the crops are mostly hay and pasture. Clover, alfalfa, and grass-and-clover mixtures are the common crops and are relatively productive. Some oat hay is grown as a nurse crop for clover or with vetch. Permanent pastures of clover, rye, or mixed grasses are common on both cleared land and stump land.

Barnyard manure and leguminous crops are used to supply organic matter and nitrogen, which becomes deficient under cultivation. Commercial fertilizers are used very little, though the 250 to 300 pounds of superphosphate, or its equivalent, added with manure, increases yields.

Nesika loam, gently sloping (ND).—Together with other Nesika soils, this phase occurs on the stronger slopes (5 to 10 percent) of alluvial fans. Aside from relief, it is very similar to the very gently sloping Nesika loam. Surface drainage is more rapid, but because the plant cover is heavy and the soil rapidly absorbs water, erosion is negligible. Relief is less favorable than for other Nesika soils, and therefore only a very small percentage of the land has been cleared for crops. A few areas are used for stump-land grazing, but most of the land has grown up to a heavy second growth of mixed conifers and deciduous trees. In cultivated crops grown and other characteristics this soil is similar to the very gently sloping Nesika loam.

Nesika gravelly loam, very gently sloping (NC).—This soil is associated with Nesika loam, very gently sloping. It occupies gently sloping alluvial fans and has a slope range of 2 to 5 percent. It is differentiated principally by the large quantity of angular and subangular gravelstones and stones of basic igneous origin that are scattered on the surface and throughout the profile.

Use and management.—The relatively rapid internal drainage of this very gently sloping soil causes crop damage during the dry season. In addition, the high gravel content limits use so much that little of

the soil has been cleared for cultivation. Most of the land is allowed to restock with timber, but some areas have been partly cleared and seeded with pasture mixtures for grazing.

Nesika gravelly loam, gently sloping (NB).—Stronger and more irregular relief (5- to 10-percent slopes) distinguish this soil from the very gently sloping Nesika gravelly loam. It commonly occurs higher on the alluvial fan deposits than that soil. In this location it is frequently shallower, less drought-resistant, and higher in content of stone and gravel. In other profile characteristics and conditions the two soils are relatively similar.

Shallowness, droughtiness, and stoniness make this gently sloping soil undesirable for cultivated crops. A few areas have been partly cleared for stump pasture and are used for grazing, but the principal use is forest.

Nesika soils, undifferentiated (NF).—These soils consist mainly of sandy, gravelly, pumicy, and stony materials of mixed origin (including granodiorite, rhyolite, andesite, and basalt) that have been deposited by swiftly flowing mountain streams on wide gently sloping alluvial fans. The soils occur in the area of pumice fall, and light-gray or nearly white pumice the size of coarse sand is commonly deposited 3 to 6 inches deep on the surface or in some places as layers or pockets in the solum.

In size and quantity of gravelstones and stones the soils vary considerably within a few feet; large boulders commonly occur adjacent to the stream channels. The texture of the surface soils and subsoils ranges from stony sand through gravelly sand, gravelly sandy loam, and in a few places, gravelly loam, loam, and pumicy sandy loam. In general the coarser stones and gravel occur higher on the fans close to the mountains or along stream channels, whereas the finer sediments are on the outlying margins and lower extremities of the fans. No positive relationships exist, however, for the streams frequently change their course and deposit coarser and finer material unconformably.

A representative profile for these soils is as follows: Under virgin forest there is a 1- or 2-inch organic mat. Gravelstones and stones are scattered over the surface of the 4- to 8-inch layer of weathered pumice fragments that next occurs. The upper 2 or 3 inches of this pumice layer is dark-gray loamy sand; the lower part, light-gray or nearly white but slightly yellow and rust-stained pumice of coarse-sand size. Underneath the pumice is 8 to 12 inches of yellowish-brown very gravelly loamy sand or sandy loam. This layer grades into a heterogeneous mixture of gravel, sand, and stone, all stained with rust brown. The sand consists of yellow, gray, and dark-gray pepper-and-salt particles. The whole soil mass is loose and porous and has little capacity for holding water.

Included in this undifferentiated mapping unit are soils occupying the broad gently sloping outwash of Mineral Creek, about 1 mile east of Mineral. These soils are less stony and gravelly than typical and include loam and gravelly sandy loam textures. They are variable over short distances, however, and commonly contain a large quantity of coarse gravel, principally of basic igneous character.

Small areas of soil without gravel in the upper 12 or 18 inches are fairly common. Pockets of pumice occur in places through the profiles. The surface soils in this area are shallow and rest upon loose angular gravel, stones, and sand. One area of about 40 acres south of Packwood, where the highway crosses Hall Creek, has a very striking purple-colored loam surface soil and subsoil, evidently inherited from parent material of very local origin.

Use and management.—Only a small acreage of the better areas of Nesika soils, undifferentiated, can be cultivated. Even so, yields are low and crops are damaged by drought. Stumps left standing after logging indicate that the trees formerly on the areas grew to immense size, probably because they were able to obtain moisture from either a high water table or underground seepage channels.

In large part, areas of these soils are droughty and unsuited to general farming. Some acreage has been cleared for farming. Most areas, however, are covered by second-growth forest trees or by a few virgin stands of fir, hemlock, scattered deciduous trees and brush and salal, Oregon grape, fern, and other common ground cover. Some part probably could be irrigated for home gardens by diverting water from the creeks, but conveyance loss and the gravelly and stony nature of the soils prohibit any large-scale operation. The few areas that have been cleared for farming are usually adjacent to the bottom lands of the Cowlitz River and are used for pasture or grazing. Yields are low, and crops are severely injured by lack of moisture.

Newberg fine sandy loam (NG).—Though widely distributed throughout the county, this soil occurs chiefly along narrow first bottoms bordering larger streams. It is derived from alluvium that came from shale, sandstone, and basalt. The alluvium is similar to that of Chehalis soils but composed of coarser and more recently deposited sediments.

The surface soil is medium-brown or light-brown slightly acid fine sandy loam, granular in most places. Between 12 and 16 inches it grades into light yellowish-brown friable fine sandy loam, and at depths between 24 and 32 inches the fine sandy loam is replaced by fairly loose loamy fine sand or fine sand. At lower depths the silt, fine sand, and coarse sand are stratified.

The subsoil and substratum are slightly acid. The substratum is faintly to moderately stained with yellow and rust brown. In many areas the surface soil closely approaches a loam texture, and in a few low areas the subsoil is more mottled.

Use and management.—Newberg fine sandy loam has nearly level to undulating, or sag-and-swell, relief that permits effective surface drainage. During periods of high water the soil is commonly flooded, but it drains rapidly when floodwaters subside. Internal drainage is fairly rapid, and shallow-rooted crops are often injured by lack of water. Deep-rooted crops usually obtain sufficient moisture from the relatively high water table.

The few uncleared areas support a heavy second-growth cover similar to that on the Chehalis soils. Much of the land has been cleared for farming. The dominant crops are spring grains, hay, and permanent pasture. The moisture-holding capacity of the soil is

lower and crops are therefore more subject to drought than on Chehalis soils. Under favorable conditions or with irrigation high yields are obtained. Management and cultural practices are similar to those used on Chehalis soils.

Newberg loamy fine sand (Nh).—This soil is widely distributed on low narrow frequently flooded very recent first bottoms lying along stream courses. It occurs in association with the other Newberg soils.

The surface soil is of brown or light-brown loamy fine sand or loamy sand, 8 to 16 inches deep. It rests on yellowish-brown loosely stratified sand and fine sand.

Use and management.—Probably less than half of Newberg loamy fine sand is cleared. Cleared areas are usually closely associated with the more productive Newberg soils. The soil is droughty and largely unsuited to crops other than permanent pasture. The carrying capacity is lower and the grazing period shorter than on the other Newberg soils. Uncleared areas are largely covered by deciduous trees and brush but afford some grazing.

Newberg sandy loam (Nk).—This soil is closely associated with Newberg fine sandy loam, and the total acreage is only slightly less. Except for surface soil texture, it has a profile very similar to that soil. Drainage and other conditions are about the same. The soil is farmed with Newberg fine sandy loam. Crops are similar, management is the same, and comparable yields are obtained.

Newberg silt loam (Nl).—This soil occupies fairly level to undulating, or sag-and-swell, areas on alluvial first bottoms. It is associated with Newberg fine sandy loam and is nearly as extensive.

The surface soil, extending to 12 or 14 inches, is brown softly granular and friable silt loam grading into light yellowish-brown silt loam or fine sandy loam that is faintly granular but easily broken into single-grain particles. The yellowish-brown silt loam or fine sandy loam grades at 26 to 32 inches into light yellowish-brown gritty loam, fine sandy loam, or loamy fine sand containing a few micaceous particles. This gritty layer is firm or massive in place but breaks easily into single-grain structure. At depths of 36 to 42 inches the gritty layer rests upon yellowish-brown stratified fine sand, loamy sand, and occasionally silt, all having faint mottlings of yellow and rust brown. The profile is slightly acid throughout.

Use and management.—Newberg silt loam usually occupies positions not subject to frequent overflow. Surface drainage is adequate, and internal drainage is moderate to rapid. The moisture-holding capacity is higher than that of other Newberg types, and the soil is better suited to crops. The better areas are excellent for garden or truck crops, but most areas are used for pasture, hay, and small grains. The soil is fertile and productive and is usually located near a water supply adequate for irrigation. Crops and cultural practices are similar to those on the Chehalis soils, but yields are usually lower and less assured, owing to the droughtier nature of the soil. Alfalfa does well, for its roots obtain sufficient moisture from a relatively high water table during the dry season, and flood periods during the winter seldom last long enough to kill the plants. Fertilization practices are similar to those used on the Chehalis soils.

948244—54——5

Nisqually loamy sand (Nm).—This soil occupies the smooth glacial outwash plain in association with the Spanaway soil. Like the Spanaway soil, it has developed under a vegetation of grass, fern, and herbs that has imparted a very dark-gray color to the surface soil. Unlike the Spanaway soil, it is free of gravel throughout the surface soil and subsoil. It is inextensive in the county.

The surface soil, to depths of 18 or 24 inches, is very dark grayish-brown sooty loamy sand. Down to 36 to 42 inches there is gradation through dark-brown to yellowish-brown loamy sand, and below that depth occurs gray, pepper-and-salt, loose porous sand that is thickly stratified and of washed appearance. Scattered gravel is not uncommon in the lower subsoil and substratum and in some places adjacent to Spanaway gravelly sandy loam occurs on the surface.

Use and management.—Nisqually loamy sand is less droughty than the Spanaway soil and has higher inherent fertility. In all but very dry years it produces under good management fairly good yields of small fruits, berries, truck crops, bulbs, and flowers. Hay and grain are also commonly grown but give low yields. Where the soil can be irrigated and is fertilized, its productivity can be considerably increased.

Olequa silt loam, gently undulating (Oa).—Widely distributed throughout the county, this soil occupies smooth or gently undulating terraces above overflow. It has a more elevated position and is more maturely developed than the Chehalis soils. The parent material is largely of mixed sedimentary and basic igneous origin, but it varies in places. In the western part of the county on terraces of the Chehalis River valley the soil is predominantly from basaltic materials and has a slightly reddish cast. Along the Cowlitz River it has some admixture of acid igneous materials but is otherwise much the same as in other areas. Although individual areas are usually small, the aggregate area is relatively large.

In its virgin condition the soil has a 1- or 2-inch organic mat. The surface soil, to a depth of 6 to 12 inches, is granular friable brown or dark-brown silt loam with usually a few soft rounded shotlike pellets scattered throughout. The upper subsoil, extending to 20 or 24 inches, has a firm consistence and usually a few round soft shot. It is a lighter brown silty clay loam than that above, and becomes yellowish brown in the lower part. It is softly granular or fragmental, and the inside of the units is more yellowish than the outside. The upper subsoil grades into a lower subsoil—a yellowish-brown silt loam of firm consistence. It is partly variegated with grayish and yellowish brown and has yellow and rust-brown mottlings. Between 4 and 5 feet the lower subsoil rests on a substratum of smooth friable and mellow yellowish-brown laminated silt and fine sand, which is slightly discolored with grayish brown and mottled with yellow and rust brown.

A few small areas having a loam surface soil are included with this soil, and the areas near Elk Creek Valley west of Doty contain scattered basaltic gravel.

Use and management.—The native cover of Olequa silt loam, gently undulating, is largely coniferous, chiefly Douglas-fir. Practically all the land has been logged, but probably only about 25 percent has

been cleared for cultivated crops. The rest is mostly in stump land and second-growth timber at various stages of growth. Some of the stump land is used for grazing and in places is seeded with a mixture of pasture grasses.

Surface drainage is adequate; internal drainage is sufficient for favorable yields but not excessive. On the cultivated areas small grains, hay, and pasture are the principal crops. The soil can be tilled easily and is fertile and productive. It is necessary to use manure, crop residues, or a rotation that contains legumes to keep the organic-matter and nitrogen contents at a level high enough to insure adequate yields of cultivated crops. Crops, especially the legumes, also respond to phosphate fertilizer. An initial application of 300 pounds an acre of superphosphate, followed by yearly applications of 250 pounds, is the usual procedure. Phosphate applied with manure or some form of commercial nitrogen at the rate of about 60 pounds of nitrogen to 100 or 120 pounds of phosphoric acid is more satisfactory than phosphate applied alone.

The principal hay crops are oats, oats and vetch, or red clover with ryegrass and timothy. Oats seeded as a nurse crop for clover or for grass-and-clover mixtures are not especially successful. The crops seeded with the oats often die from lack of moisture after the oat crop is harvested. Hayfields are usually pastured after the first crop, but the plants usually do not make much growth until the fall rains. To maintain good pasture, the land should be seeded and kept productive by fertilization and careful management. A pasture mixture recommended by the State Extension Service (7) is made up of English and Italian ryegrasses, orchard grass, tall meadow oatgrass, Kentucky bluegrass, and common white, red, and alsike clovers.

Yields are variable, depending on management and fertilization practices, but usually higher than on the Salkum and other old-terrace soils. Oats yield 1 or 2½ tons of hay or 50 to 70 bushels of grain an acre; wheat, 30 to 40 bushels. Oat-and-vetch hay yields 2 to 4½ tons an acre. Mixed pasture grasses usually yield 3 to 4 tons. Alfalfa is not extensively grown but is easier to establish than on the older soils.

Olequa silt loam, sloping (OB).—This soil has sloping relief (5 to 15 percent) and usually occupies narrow and elongated sloping areas between terrace levels. It is generally shallower, and because of its relief, is less easily worked than the gently undulating Olequa silt loam. Otherwise it is relatively similar, and crops, yields, and farm practices are practically the same on both soils.

Olympic silty clay loam, rolling (OD).—This soil occupies several large areas on rolling hills where basalt is the dominant underlying rock. It developed on rolling or sloping relief and has slopes ranging up to 15 percent. Surface drainage is well established; underdrainage is good.

In its virgin condition, there is a mat of partly decomposed dark-brown organic material 1 or 2 inches thick at the surface. Abruptly replacing the organic mat is the brown or reddish-brown granular friable silty clay loam surface soil, 6 to 10 inches thick, that contains a moderate quantity of small rounded shotlike pellets high in content of iron and manganese.

Beneath the surface soil is the mildly acid, pale reddish-brown or light-red silty clay upper subsoil, which is friable and granular and contains a few soft shotlike pellets. At depths of 18 to 24 inches this layer grades into the lower subsoil, a massive and slightly compact light-brown or pale reddish-brown silty clay loam or clay containing very small angular dark-purple basalt fragments.

At depths of 3 to 4 feet the lower subsoil grades into the moderately acid substratum, or parent material, which is slightly compact but permeable clay having a pale reddish-brown color variegated with yellow and purple staining and concretions. Solid basalt bedrock occurs at depths ranging from 3 to 20 feet or more. Fragments of weathering basalt may occur in the solum and parent material.

When this soil is cultivated, the acid organic layer becomes mixed with the mineral soil, forming a slightly to moderately acid, reddish-brown or reddish surface layer. The cultivated surface layer loses some organic matter and is consequently lighter colored than where undisturbed.

Because slopes vary there is some variation in the soil profile. On the stronger slopes the soil commonly contains the most stones, and on the lower slopes it is frequently browner. In some particularly well-aerated spots the soil is fairly red. In the central part of the county, particularly south of the Cowlitz River, both the surface and subsoil are browner and the depth to underlying bedrock, although variable and usually more than 3 feet, is less than in the western part of the county. One area of 40 to 50 acres northwest of Packwood has a surface deposit of light-gray pumice 2 to 6 inches deep. In this area the soil underneath the pumice is also yellower and lighter textured than elsewhere.

Use and management.—Olympic silty clay loam, rolling, was originally heavily forested with Douglas-fir, hemlock, and cedar. Timber yields were exceptionally good. Areas that have not been cleared for farming are slowly restocking to similar forest types. Alder, vine maple, hazelnut, salal, Oregon grape, fireweed, bracken, and other brush and shrubs quickly take over logged-off areas and aid in keeping erosion loss at a minimum. Erosion is not severe, even on the clean-cultivated slopes, because the soil has excellent structure that allows rapid penetration of air and water.

The cleared and cultivated acreage is small and occurs principally southwest of Adna and northwest of Winlock. Clearing costs are very high, but once cleared the soil is fairly productive. Farming is hindered to some extent by the rolling relief. The soil is deficient in active organic matter and available nitrogen, and under cultivation it needs barnyard manure, crop residues, or a proper rotation containing legumes to keep its fertility at a level suitable for crop production. Applications of either superphosphate or treble-superphosphate with some form of nitrogen aid materially. So far, addition of lime has not proved particularly beneficial. Where barnyard manure is used the customary phosphate application is 250 to 300 pounds an acre a year.

The principal crops are hay, small grains, and pasture. Wheat and oats are the leading grain crops. Winter wheat yields 20 to 30 bushels; winter oats, 40 to 60. Spring wheat and oats usually yield

less. Of the hay crops, oats, oats and vetch, or grass hays with red clover are most commonly used. Oat hay yields 1 to 2½ tons an acre if fertilized. Oat-and-vetch hay yields much higher. Grass hay yields 1½ to 2 tons.

Fertilizer recommendations depend mostly upon the type of crop and previous crop history of the soil. For oat hay, on land that has been depleted of its nitrogen by a nonleguminous crop the previous year, a mixture of 60 pounds of nitrogen and 80 pounds of phosphoric acid is desirable. If the soil has been planted to a leguminous crop the previous year or has received applications of manure, the quantity of nitrogen can be decreased about one-third. Oats for grain require about 40 pounds of nitrogen and 80 pounds of phosphoric acid, but if the soil has had applications of manure or was in leguminous crops the previous year, it does not need the nitrogen.

Nurse crops do not do well and take moisture from other crops. Alfalfa is grown on some of the land but is hard to establish. For best results, pastures and grass hay meadows should be reseeded when necessary. On cut-over land successful seeding is best done after a burn, because ashes make a favorable material for the seeds to germinate and grow in; furthermore, the burning eliminates some of the severely competing natural vegetation, especially bracken. Good pasture is obtained on burned areas if brush and logs are removed and the stand of grass is maintained.

Olympic silty clay loam, hilly (Oc).—Except for occupying hilly areas considered unfavorable for cultivated crops, this soil is similar to the rolling Olympic silty clay loam. The soil is not cropped extensively, for it is difficult to use farm machinery and the steeper slopes would be in danger of accelerated erosion if cultivated.

This soil occupies relatively large areas of irregular relief (15- to 30-percent slopes). Some small areas having lower or higher slopes are also included. The soil on the stronger slopes is usually shallower and contains more stones than is typical, but it has fewer stones than either the rolling or hilly Olympic stony silty clay loams. Surface drainage is much more rapid than on the rolling phase, and the soil is also more droughty during summer months, especially on southern exposures and on the stronger slopes or at the crests of ridges.

Unfavorable features previously mentioned limit the use of the soil to forest. The original timber was excellent, and many logged areas are restocking well. Under favorable circumstances areas not restocking could be reseeded or replanted. Some areas adjacent to farm land that have not restocked to merchantable timber might be partly cleared and sown to grass seed for stump-pasture land.

Olympic stony silty clay loam, rolling (Or).—This soil occupies a relatively small total area in a few isolated places. It usually occurs adjacent to areas of other Olympic soils. Slopes range from 6 to 15 percent. The soil has limited use because angular basaltic stones and gravel are scattered over the surface and throughout the profile. The soil differs from Olympic silty clay loam, rolling, in being more stony and much shallower. In places bedrock occurs within less than a foot

of the surface. Some areas that have been logged and are only slowly restocking to marketable timber could be used to good advantage for grazing, but the soil is limited principally to forestry.

Along the Tilton River west of Morton are some included areas in which the soil has been derived from mixtures of acidic gravel and silty materials mixed with the basalt. In other features, however, these included areas are similar to Olympic stony silty clay loam, rolling.

Olympic stony silty clay loam, hilly (OE).—Areas of this soil are relatively large. Except for its irregular or hilly relief (15- to 30-percent slopes) the soil is very similar to the rolling Olympic stony silty clay loam. It contains many more angular stones and pieces of gravel, however, and is also usually much shallower. Most of this soil occurs in the eastern part of the county. It is used solely for the production of forest products.

Along the Tilton River the basaltic parent material has become mixed with material similar to that for the Wilkeson soils, and consequently this soil to some extent resembles those of both the Wilkeson and Olympic series. Some small areas are nearly typical of the Wilkeson soils; other small adjacent areas are fairly typical of the Olympic soils. Had their use been less limited these included soils might have been mapped separately. They are exceptionally gravelly and stony. The gravel and stones are chiefly from basaltic materials, although they contain some acid materials.

Onalaska silt loam (OG).—This soil occupies slopes of 0 to 5 percent on terraces of the valley floor. Surface drainage is slow but well established; internal drainage is only partly restricted by the compacted substratum. The water table is usually fairly close to the surface, and slight changes in elevation are associated with changes in drainage relationships.

The soil profile is variable. Usually, however, the surface soil is dark-brown mellow and friable silt loam containing many small rounded shotlike pellets. At 10 or 14 inches the surface layer grades into yellowish-brown silt loam upper subsoil, which has a mellow, soft, crumb structure and contains a few shot pellets. Below 2 feet the subsoil is slightly compact, heavier textured, and slightly mottled with yellow and rust brown. At depths of 2½ to 3½ feet it rests abruptly on a yellowish-gray or yellowish-brown substratum of partly cemented and relatively strongly weathered gravel, clay, and sand similar to the material underlying Onalaska silty clay loam. In places a 6- or 10-inch layer strongly mottled with yellow and rust brown is common immediately above the substratum.

Varying quantities of rounded gravel are scattered on the surface and through the solum. The solum of this soil does not appear to be related to the substratum material. The soil seems to have developed from a later deposition of finer sediments, which are probably made up to a large extent of material eroded from the Wilkeson and Cinebar soil materials. The soil profile may vary slightly in some areas.

Use and management.—All of Onalaska silt loam has been logged, but only a few acres are cleared. Most of the land is covered with brush and stumps and is slowly restocking to timber or has been

partly cleared for stump pasture. The cultivated land produces hay, grain, and pasture grasses. The yields obtained and cultural practices used are similar to those on Onalaska silty clay loam.

Onalaska silty clay loam (OH).—This soil developed most extensively on the older and higher postglacial stream terraces where slopes range from 0 to 5 percent. The immense quantity of water necessary to form these terraces indicates they probably were formed during or immediately following some early glacial period.

Under virgin conditions there is a 1- or 2-inch organic mat at the surface, and below this a dark-brown granular and friable silty clay loam. At 8 to 12 inches this material grades into brown granular friable silty clay loam.

The subsoil within 20 to 26 inches of the surface is light-brown or yellowish-brown heavy silty clay loam or light clay. It is firm to very slightly compact when dry but friable and mellow when wet; it breaks into small fragments or spherical units, the surfaces of which are faintly coated with colloid stains.

At depths of 32 to 42 inches the subsoil rests abruptly on yellowish-brown moderately compact strongly weathered and highly stained gravel, sand, and clay. The gravelstones are highly weathered, and many of them are partly decomposed. They are highly coated and colored with rust-brown, yellowish-brown, and dark manganese stains. With increasing depth the parent material becomes less compact and less weathered, but it is still highly stained.

Scattered rounded gravelstones of mixed origin occur throughout the solum, and a few soft shotlike pellets occur in the surface soil and upper part of the subsoil. This soil is much more youthful than soils of the Salkum series but older than those of the Olequa. As evidence of this, its parent material, though of mixed granitic and basaltic origin and closely resembling that of the Salkum soils, has a much lower content of clay and is much less weathered.

In mapping this soil, areas on old terraces in the upper valley of the Chehalis River south of Boistfort School and east of Doty were included. In these areas the parent material contains a higher percentage of gravel of basic igneous origin, but the quantity of gravel in the solum varies considerably. The degree of compaction in the substratum and the extent of weathering is about the same as that in other areas of this soil. A few small areas having gentle slopes (5 to 15 percent) are also included.

Use and management.—Surface drainage of Onalaska silty clay loam is slow but well established. The substratum is compact enough in the upper part to prohibit excessive internal drainage. As on most of the well-drained soils of the area, crops are damaged by lack of moisture late in summer. The total area is small and a large part has been logged and consists of cut-over land slowly restocking to second-growth timber, or, in some instances, partly cleared and used for grazing. Probably less than one-fourth is cleared and under cultivation. Hay and small grains are the principal cultivated crops. Yields and cultural practices are similar to those on the Salkum soils.

Pilchuck sand (PE).—This soil occurs on low first bottoms and is derived from sandy materials similar in origin to those of the Puyal-

lup soils. This parent material usually contains an admixture of glacial rock flour from melting glaciers on Mount Rainier and Mount Adams.

The relatively ill-defined profile is characterized by a surface soil of light-gray or olive-gray pepper-and-salt loose sand lying upon a subsoil of loose porous olive-gray pepper-and-salt interstratified sands. Gravel occurs at varying depths between 2 and 6 feet or more.

The soil occupies a low position adjacent to the river or to riverwash material, where it is frequently flooded and subject to both erosion and deposition. In this position it is often traversed by small gravel bars and frequently changing stream channels. Soil-forming agencies have not had sufficient time to modify appreciably the profile; the gray color is an inherent not a developed characteristic.

Use and management.—Pilchuck sand supports scattered firs and hemlocks and heavy stands of alder, poplar, maple, vine maple, and willow. Some sparse grazing is afforded in spring and fall. The soil is excessively droughty and of little value for agriculture. Only a small percentage is farmed. Many areas appear to have been cleared and subsequently to have received a deep deposit of sand over the better soil. In these sites the fine materials are not deep enough to have any important effect on the agricultural value. Yields are low and unassured. Permanent pastures have a low carrying capacity and afford grazing for only a short time.

Pilchuck loamy sand (Pc).—This soil consists principally of recent sandy depositions that are in places very similar to Puyallup loamy fine sand but retain a grayer color. It occurs in many scattered areas on slightly lower positions in association with other Pilchuck soils.

The surface soil, 12 to 18 inches deep, is gray or light brownish-gray loose loamy sand having a slight pepper-and-salt appearance. It grades into olive-gray pepper-and-salt loose interstratified sand, which in turn rests on stratified gravel at a depth of 4 to 10 feet.

In some areas this soil is deposited over Puyallup soils or in a few sites over Siler soils. In these places the deposit is usually over 2½ to 3 feet deep and the underlying soils have no appreciable effect on crops.

Use and management.—Pilchuck loamy sand is subject to floods and attendant erosion or deposition of finer or coarser sediments. It is very droughty and has little agricultural value other than for permanent pasture. It is largely uncleared and supports a scattered growth of conifers and relatively heavy growth of mixed deciduous trees and brush. Permanent pastures have a low carrying capacity and afford grazing for only a short period.

Pilchuck loamy sand (over Puyallup fine sandy loam) (Pd).—This soil is mapped where a shallow layer of Pilchuck loamy sand has been deposited over Puyallup soils. The deposits are 1½ to 2 feet deep, but the depth is variable within short distances. Most of this material was deposited on areas of farm land during the 1933 flood. For a few years afterward crops were difficult to establish. Now hay crops do well in favorable years, and where alfalfa can be established

it usually obtains sufficient moisture from the heavier materials to maintain itself. Nevertheless, the soil is too loose and droughty for most crops, and yields are usually low.

Pilchuck gravelly sand (PB).—Making up this soil are small areas adjacent to riverwash material or former beds and channels of the river where alders, willows, maples, and shrubs have gained a foothold and the soil is too stabilized to be classified as Riverwash. The profile consists of mixed or stratified gravel and sands, but some small areas intricately associated with extremely gravelly areas are relatively free from gravel. This soil is subject to annual floods and is unsuited to agriculture.

Pilchuck and Puyallup loamy sands (PA).—These soils form a complex that occurs in two or three small areas. Separation of the two soils is impossible, principally because the individual areas are inaccessible. The complex consists largely of Pilchuck and Puyallup loamy sands, although other textures are probably included. None of the land is cleared or farmed. It supports a heavy cover of fir, hemlock, and cedar mixed with alder, maple, poplar, and other deciduous trees, brush, and shrubs.

Puget silt loam (PF).—This inextensive soil occurs in small poorly drained back-bottom areas in association with the Puyallup and Sultan soils. It is the most poorly drained member of this catena.

The surface soil is light brownish-gray or grayish-brown heavy silt loam. It has soft crumb structure, is slightly acid, and is slightly mottled with rust brown. At variable depths (4 to 12 inches) it is underlain by yellow, rust-brown, and bluish mottled and stained gray or bluish-gray silty clay loam that at lower depths is stratified with fine sand, silt, and clay.

Use and management.—Puget silt loam supports a thick cover of deciduous trees, brush, and shrubs and, in open or semicleared areas, sedges and water-tolerant grass. The water table is high; the soil is flooded during winter and spring and remains saturated during summer unless artificially drained. None of this soil is being farmed. Some partly cleared areas provide good grazing.

Puyallup fine sandy loam (PG).—Nearly level or gently undulating alluvial flood plains are occupied by this soil. The parent materials are of mixed origin and typically contain various quantities of glacial rock flour. Although not extensive, this soil is the most extensive one in the Puyallup series. Nearly all of it is in the vicinity of Toledo.

The surface soil, extending to 12 or 14 inches, consists of light brownish-gray or grayish-brown friable fine sandy loam. Underlying is pale brownish-gray or slightly yellowish-gray friable fine sandy loam or sandy loam. At variable depths between 28 and 36 inches the sandy loam grades into gray and brown or light olive-gray pepper-and-salt stratified sand and fine sand.

Along the upper part of the Cowlitz River, principally near Riffe, most of the areas have sandy loam surface soil, and a few areas contain some gravel or in a few places gravel bars, which are indicated on the map by gravel symbols.

Use and management.—Puyallup fine sandy loam occupies fairly level or undulating relief and has good surface drainage. Internal drainage is not restricted and in many places is excessive. Crops are usually injured by lack of moisture during the dry season. This soil is flooded only during years of excessively high water, and the floodwaters are quickly carried off after the river subsides. During floods the soil may be changed considerably, as the waters are usually swift-flowing and erosive.

Probably less than half of Puyallup fine sandy loam is farmed. In a few areas truck crops are raised for local markets, but the soil is usually farmed for crops suitable to the dairy industry, principally small grains, hay, and pasture. Early-maturing crops, as oats or oats and vetch, usually do best because they can be harvested before the dry season. Other hay crops are mixtures of clover and ryegrass or timothy. Permanent pasture mixtures include red, alsike, and common clovers, English and Italian ryegrasses, orchard grass, timothy, and Kentucky bluegrass. Alfalfa is also grown and yields 3½ to 5 tons an acre. The pasture-carrying capacity is usually low. Yields depend to a large extent on the distribution of relatively variable rains in spring and early summer. Under favorable conditions very high yields are obtained, for the soil is fertile and responds to good management. Irrigation would assure a crop and probably increase yields, but it is not practiced.

Puyallup loamy fine sand (PH).—Although it is closely associated with the other members of the Puyallup series, this soil usually occupies a lower position closer to the Pilchuck soils. Its materials have been deposited long enough for some slight profile development and are not so dull gray nor so coarse as those of the Pilchuck soils.

Internal drainage is free or excessive; surface drainage is well established. The soil drains rapidly and is more subject to winter flooding than the other soils of the Puyallup series. Floods that overflow the land may cause many changes in the upper part of the profile.

The surface soil is light grayish-brown or brownish-gray loamy fine sand or occasionally loamy sand. The material grades to a lighter color and texture with depth. The substratum is light olive-gray or gray and brown pepper-and-salt stratified sand and fine sand. The depth to the substratum is variable but seldom exceeds 30 inches and is commonly not less than 16 inches. This substratum is open and porous and has little capacity for holding moisture.

Use and management.—Puyallup loamy fine sand is less suited to farming than other soils of the Puyallup series, and only a small area has been cleared. Uncleared areas support mixed coniferous and deciduous trees and brush that afford sparse grazing. Cleared areas are used for permanent pasture or hay. This soil is droughty and has lower carrying capacity and yields than Puyallup fine sandy loam.

Puyallup silt loam (PK).—This soil is closely associated with Puyallup fine sandy loam and has similar relief and positions. It is less extensive and usually occurs farther back from the river where the relief is more even.

The surface soil consists of 12 to 14 inches of grayish-brown or light brownish-gray silt loam that has soft crumb structure and is very

friable. The surface soil grades into mellow, pale brownish-gray very fine sandy loam or sandy loam that extends to depths varying between 30 and 48 inches. The lower part of this pale brownish-gray layer is faintly mottled with yellow and rust brown. Next occurs light olive-gray pepper-and-salt stratified sand, loamy fine sand, and silt, which often show some faint brown or rust-brown staining. The soil is slightly acid.

Use and management.—Surface drainage of Puyallup silt loam is effective, and internal drainage is free. The moisture-holding capacity is greater than on Puyallup fine sandy loam, and yields are higher. The soil is fertile, highly productive, and suited to a wide variety of crops. A large part of the soil is farmed to hay, small grain, and pasture crops for dairy cattle. Distance to market is the principal factor limiting use of this soil for other crops.

Hay land and pastures usually receive about 6 tons an acre of barnyard manure. In some instances hayfields and pastures are fortified with 250 to 300 pounds of superphosphate an acre. Clover or alfalfa used in rotations is usually sufficient to maintain the organic-matter content and nitrogen supply.

Reed clay (RA).—Low swampy back bottoms on the valley floor are occupied by this soil, the poorly drained swampy member of the Newberg, Chehalis, Wapato, and Reed soil catena.

The surface soil, 6 to 10 inches deep, is brownish-gray or dark brownish-gray clay with an angular granular or fragmental structure. The upper 2 or 3 inches is highly organic or peaty under virgin conditions. Some rust-brown spots occur nearly to the surface.

Underlying the surface soil is brownish-gray or dark brownish-gray clay, which has a coarse nut structure and is mottled with rust-brown and faint bluish reduction colors. At a depth of 14 or 16 inches, this mottled clay grades into a gray or bluish-gray stiff and tight clay that is stained with small spots of rust brown and has a slightly blocky structure. The stiff clay becomes slightly lighter in color and more plastic with depth, and at about 40 inches rests on the lower subsoil of gray or pale olive-gray gleylike clay or stratified clay and sandy clay. The lower subsoil varies from lighter gray with yellowish staining to bluish gray, the lighter color occurring more in areas in the smaller valleys.

Use and management.—Uncleared areas of Reed clay support a scattered second growth of hemlock and cedar, some fir, and a dense growth of alder, maple, ash, vine maple, and willow. The undercover is heavy and consists of spiraea, wild rose, blackberry, skunkcabbage, and sedges. The slope is usually sufficient for open-ditch drains. In view of the limited number of crops that can be grown, tile drainage is expensive, and difficult because of the tight subsoil. The soil can be readily worked under optimum moisture conditions, but when too dry is very hard and usually has large blocks that give it the appearance of an adobe soil.

In favorable years excellent yields of hay and grain are obtained, but yields are not always assured, and often conditions are such that planting is impossible at the right time. Most of the soil is used for grass hay or permanent pasture. Mixtures of ryegrass and alsike clover with timothy, orchard grass, and Kentucky bluegrass are used.

Some of the wetter areas are planted to Reed canarygrass, which produces high yields of hay or has a high carrying capacity when grazed.

Reed silty clay loam (Rb).—Reed silty clay loam is closely associated with Reed clay and occurs in similar back-bottom positions. It is distinguished from Reed clay by a silty clay loam texture that is slightly more friable.

A large part of the soil is cleared or partly cleared and used for the same crops as Reed clay, with similar yields. Tillage is slightly less difficult because the surface soil has a lighter texture.

Riffe sandy loam (Rd).—This soil is closely associated with the Winston and Olequa soils, which have similar parent materials. It differs from the Winston soils in being relatively free from gravel, and from the Olequa soils in having a more open and porous sandy substratum.

This soil is not extensive and occurs on stream terraces ranging from a few feet above floodwaters to more than 100 feet above the river. The difference in levels or in relative age of the different terraces is manifested by a variation in the profile. The lowest, or more youthful, soils are usually duller, slightly grayish, and contain only a few scattered shotlike pellets, whereas the oldest soils, occupying the highest terraces, having developed a strong yellowish-brown subsoil and a moderate quantity of shot in the surface soil and upper subsoil.

This soil occupies level to gently undulating relief (2- to 5-percent slopes). One included area of approximately 40 acres on the south side of the Cowlitz River, just west of the bridge north of Mossyrock, has more rolling relief and slopes ranging up to 15 percent.

In virgin areas Riffe sandy loam has a surface layer of partly decomposed organic matter 1 or 2 inches thick. The upper 5 or 6 inches of the mineral surface soil is dark-brown sooty fine sandy loam. Organic matter is largely lost in cultivation, and the surface 10 to 12 inches in cultivated fields is brown friable sandy loam, which in places closely approaches loamy fine sand. The surface layer is underlain by a 6- or 8-inch gradation zone of brown to yellowish-brown friable sandy loam. A few shotlike pellets are scattered throughout the surface soil and down into the upper subsoil. The subsoil—a moderately yellowish-brown single-grain loamy sand—extends from 32 to 36 inches, where it rests on loose loamy sand, dominantly yellowish brown but variegated with dark-gray and light-gray sands. The layer of loamy sand grades into loose gravel and sand at varying depths below 3 feet, but it is usually deeper than 4 feet.

Use and management.—Surface drainage of Riffe sandy loam is adequate, and internal drainage is free to excessive. The moisture-holding capacity is not sufficient during the dry season, and only the early-maturing crops grow successfully. Nearly all the land has been logged, and most of it now supports a good stand of second-growth fir. The small acreage in cultivation is used for hay and grain. Oats are the principal crop. Yields are variable and depend to large extent on the distribution of spring rains. Management, yields, and fertilization practices correspond closely to those used on Winston loam, gently undulating.

Riffe loam (Rc).—Several small areas of this soil occur in close association with Riffe sandy loam, which occupies similar nearly level to undulating stream terraces. On the north side of the Cowlitz River just west of the bridge north of Mossyrock, there is one area of this soil with slopes of 5 to 15 percent.

The 10- to 12-inch surface soil is brown friable loam or gritty loam containing a few shotlike pellets. In virgin areas the upper 4- or 5-inch part of this layer is much darker colored and is covered by a 1- or 2-inch layer of organic duff. The subsoil is yellowish-brown gritty loam or sandy loam. It grades into sandy loam or fine sandy loam below 24 inches, and at 28 to 36 inches is the loose loamy sand substratum. At varying depths below 36 inches the substratum, in turn, rests on gravelly layers.

Use and management.—In nearly all respects Riffe loam is similar to Riffe sandy loam. The moisture-holding capacity is somewhat higher, making it slightly more productive. Very little of the land is farmed.

Rifle peat (Re).—In a representative profile of this soil the surface 6 or 10 inches consists of dark-brown or brown moderately acid coarsely granular woody peat containing many decaying wood fragments. This surface layer grades into a layer of raw brown woody fragments mixed with sedge fragments, which is, in turn, replaced by brown moderately acid raw sedge peat. At variable depths below 2½ feet this raw peat grades into a bluish-gray colloidal clay. Faint mottlings, mostly bluish reduction colors, are evident.

Admixtures of spiraea, sedges, and colloidal materials give the surface layer a variable structure and a tendency to form lumpy cakes on drying. Commonly the lower subsoil is a mixture of lenses of woody, sedge, and colloidal peats in varying order. Often highly colloidal clay lenses also occur. South of Swofford and especially around Davis Lake near Morton, the surface of woody material is shallow and mixed with sedge, whereas the subsoil is dominantly laminations of raw sedge peat. In the Davis Lake area the peat deposits are very deep.

Use and management.—Virgin areas of Rifle peat are highly saturated and swampy. They support cedar, hemlock, some fir, alder, vine maple, ash, cottonwood, and a dense undergrowth of willow, spiraea, sedges, wild rose, snowberry, skunkcabbage, and other brush and shrubs. The soil has to be drained before it can be used. Adequate drainage is usually accomplished with open ditches. The water table, however, should be held at a level high enough to supply adequate moisture for plant growth.

Rifle peat is very productive when properly handled. Most of the peat in this county is utilized for hay, pasture, or small grains. Alsike and timothy mixtures for hay and pasture, and in the wetter areas, Reed canarygrass, are commonly used. Oats produce about 2 tons if cut for hay or 60 to 80 bushels if harvested for grain. Addition of farm manure is the principal fertilization practiced. The soil is deficient in phosphorus and potash, and farm manure supplemented with these elements, usually in a ratio of about 4–10–10, is beneficial. Usually lime is necessary only for the more acid areas.

This peat soil settles on being drained; cultivation improves its surface structure.

Rifle peat, shallow (over dense clay) (RG).—This soil consists of areas in which the peat deposit is less than 2½ feet deep. A succession of layers of colloidal, sedge, and woody peats usually occurs only in the deper areas, and even there the sedge and colloidal layers are thin in many places. In the shallower areas the whole section is often entirely woody material.

The surface soil consists of dark-brown rotted woody peat and some admixture of sedge and colloidal peat. In nearly all places this layer is underlain at depths of 6 to 30 inches by stiff bluish-gray clay similar to that underlying the Reed soils. Along Hanaford Creek the depth to mineral material is 6 to 10 inches, whereas in Pleasant Valley and other areas it is 16 to 24 inches.

Use and management.—Native vegetation and cropping practices on this peat are similar to those on Rifle peat. This soil, however, is less desirable, especially in the area around Hanaford Creek, where it is very shallow. Peat soils tend to settle after drainage and cultivation, so shallow deposits often become unsuitable for crops.

Rifle peat, pumicy (RF).—This soil occurs only in the Big Bottom area and consists of woody peat containing a layer of pumice.

The surface soil is characterized by brown or dark-brown partly decomposed granular woody peat, which averages between 4 and 12 inches deep. The surface soil rests upon a 4- to 10-inch layer of slightly iron-stained light-gray coarse loose and porous pumice. Below the pumice layers the soil usually consists of layers of woody, sedge, and colloidal peats that grade at depths varying between 2½ to 10 feet or more into a bluish-gray, rust-brown stained, mineral subsoil similar to that of the Schooley soils. The succession of layers is not always as described. Not all layers are always present, nor do they always occur in definite order. In places the peat below the pumice is almost entirely raw woody or raw matted sedge materials.

Use and management.—The total area of Rifle peat, pumicy, is relatively small. About one-third of the total area is in use, nearly all for pasture. This soil is fertile and productive when properly drained and managed. Like other soils in this area having a layer of pumice close to the surface, capillary water movement is retarded, and during the dry season the surface peat becomes very dry. To some extent this limits the use of the soil. Natural vegetation, crop yields, and farm practices are similar to those on Rifle peat.

Riverwash (RH).—This land type occupies narrow elongated areas bordering the river or is in recently abandoned river beds. It is either barren of vegetation or supports scattered cottonwood, willow, and other trees and brush. The areas consist of stream-deposited sand, gravel, and stones and are frequently overflowed and altered by erosion and deposition. They have no agricultural value.

Rough broken land (RK).—Bodies of this land are narrow, have steep broken relief, and occur along gullies, stream channels, or entrenched valleys. Many areas include short steep slopes and escarpments between terrace levels. Soil profiles are usually thin and poorly developed and owing to the heterogeneous mixture of parent materials,

in many instances do not conform to any particular series. The soils are commonly very gravelly, especially along the terraces where they conform principally to the Winston series; other materials, however, influence the soils. In many places one steep slope cuts through several different planes of parent materials.

The thin soils and steep relief are unfavorable for farming, and none of the land is used for that purpose. In some places valuable forest trees can be grown. For the most part these areas should be left in their native vegetative cover to prevent serious erosion.

Rough broken land (Olympic soil material) (Rl).—This land type occupies relatively narrow scattered areas—precipitous slopes, gullies, and canyons along the major streams and rivers or steep broken land of 20 or 40 percent slopes bordering areas of Olympic soils. Soil development has been slow; soil profiles are thin but show relationship to those of the Olympic series. Bare outcroppings of basalt are common, and the soil material is stony. Inclusions of other materials probably occur in some areas.

The thin soils and steep irregular relief are unfavorable for agriculture, and none of this land is used for farming. Its principal use is for timber production.

Rough mountainous land [4] (Olympic soil material) (Rm).—Approximately 61 percent of the total area of rough mountainous land, or approximately 26 percent of the total area surveyed, is occupied by this land type. It consists principally of high-rising mountainous areas and outlying steep foothills that are considered nonagricultural. Small inaccessible areas of arable land may be included. Soil characteristics are usually poorly developed; the soils are shallow and stony. Bare rock outcrops are common.

In general the soils closely resemble those of the Olympic series, but they are much more variable in depth and degree of stoniness. The surface soils are brown to reddish brown; the subsoils, usually slightly heavier and reddish brown. The depth to underlying bedrock ranges from a few inches to 20 feet or more. The dominant rock is basalt, but inclusions of sandstone and shale are common and give rise to small areas of soils similar to those of the Melbourne series.

This land type includes the higher mountains of the Coast Range in the western part of the county and the outlying spurs of the Cascade Range in the central part. Elevations range from 500 to nearly 3,000 feet in the western part of the county and to nearly 4,000 feet in the central part. Probably more than half of the area has been logged; the other half is in virgin forest. The dominant timber is Douglas-fir, which thrives in this climate and grows to huge size. With it to a lesser extent are Western redcedar and Western hemlock. The luxuriant undercover consists of varieties common to the county. Deciduous trees are scattered throughout the forest and especially on the wetter areas. Logged-off land is quickly invaded by fireweed, salal, Oregon grape, bracken, wild blackberry, and other brush and shrubs that produce a thick and heavy cover. Douglas-fir, alder, and maple, closely follow the after-logging vegetation.

---

[4] Areas of Rough mountainous land were surveyed only in reconnaissance, and the dominant parent rock of the soils was only roughly delineated.

Runoff and drainage are rapid on some of the steeper slopes, but the heavy cover prevents accelerated erosion. In many places reforestation has been slowed considerably by severe burning and reburning after logging and by the failure of lumber companies to leave enough seed trees. The future of the vital lumber industry depends to large extent upon careful handling and reforestation of these mountainous areas.

Rough mountainous land (Olympic and Cispus soil materials) (Rn).—This land type occurs only in the area of pumice fall extending from Kosmos to Packwood in the eastern part of the county. The underlying parent rock is dominantly basic igneous, although inclusions of granitic rock occur to some extent.

The distinguishing feature of this land type is the layer of light-gray fine pumice that covers the surface to a depth of 4 to 12 inches. In places west of Randle this land type includes deposits of yellowish pumice ranging from the size of coarse sand up to 2 inches in diameter and from a few inches to several feet deep. In many respects this soil is similar to those of the Cispus series. The underlying material is buff or yellowish and lighter textured than that for the Olympic soils.

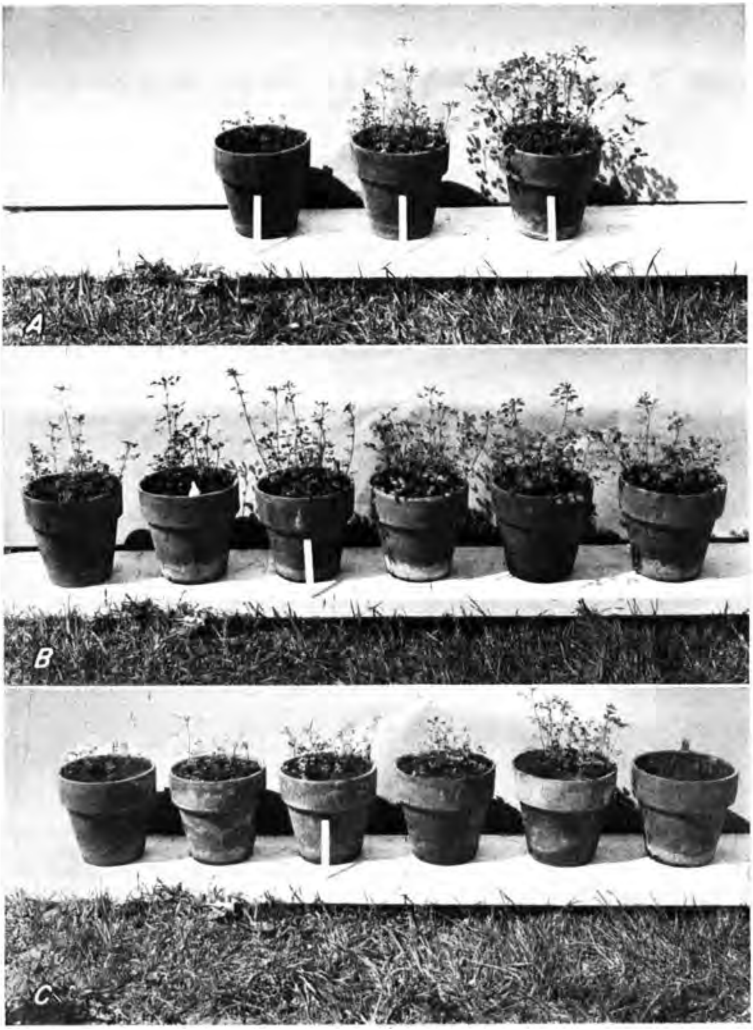
Tree and plant roots and water readily penetrate the loose pumice to the underlying soil, even where the pumice layers are deepest. Erosion is at a minimum. In most places the pumice enhances forest growth by acting as a surface mulch that conserves moisture in the underlying soil. Forest growth is luxuriant and similar to that on the other land types. The use of the land is restricted to forest.

Rough mountainous land (Olympic, Wilkeson, and Cispus soil materials) (Ro).—Approximately 8 percent of the total land area surveyed is occupied by this land type. It is accessible only by isolated foot trails or logging railroads. Only a reconnaissance survey was attempted, and because types were so variable, differentiation among them was impracticable.

Most of the land bordering the highway consists of Wilkeson soil material, whereas most of that bordering the national forest boundary has a surface layer of pumice. Between these two main areas and intermixed with them are soils derived principally from basalt but having inclusions from sedimentary rock. Probably half the total area is in virgin forest; the other half has been logged and is in various stages of reforestation with second-growth timber. This land is used only for forest.

Rough mountainous land (Wilkeson soil material) (Rp).—About 6 percent of the area surveyed is made up of this soil type. The underlying country rock, like that of all the mountainous land, is primarily basalt. Glacial activity occurring previous to the Vashon glaciation deposited over most of the area a thin veneer of till, rubble, and fine soil material similar to that from which the Wilkeson soils developed. In these steeper and rougher areas the development of normal soils has been retarded, and the soils resemble the Wilkeson soils only in their broader aspects. They are usually shallower and much more stony, and bare rock outcrops are common.

A, Young strawberries on Salkum silty clay loam, undulating.
B, Schooley silt loam on flood plain in foreground; Siler silt loam on slightly higher bottom near house.
C, Recently logged Wilkeson silt loam, rolling. Logging leaves a tangle of logs, stumps, and brush that makes clearing difficult.



A, Unfertilized alfalfa plants showing relations between age of soils and their fertility. Salkum silty clay loam soil on left is very old, Cinebar silt loam soil in center much less so, and Chehalis silty clay loam on right the youngest.

B, Growth of alfalfa on Cinebar silt loam soil under different treatments. Left to right, treatments are (1) check (no treatment), (2) phosphorus added as treble-superphosphate, (3) phosphorus added as superphosphate, (4) nitrogen, phosphorus, and potassium added, (5) phosphorus and manure added, and (6) calcium carbonate (lime) added at the rate of 3 tons an acre.

C, Growth of alfalfa on Salkum silty clay loam soil under same treatments, left to right, as listed for Cinebar silt loam soil in *B*, above. Plants show best response to application of manure and phosphorus, and a better response to superphosphate (containing gypsum) than to treble-superphosphate. Lime decreased growth on this soil and was not beneficial on the Cinebar. Poorer growth of check and poorer response to the various treatments indicate that this soil is less fertile than Cinebar silt loam soil.

The surface soil under an inch or two of organic duff is softly granular brown silt loam overlying yellowish silt loam or silty clay loam mellow subsoil. The depth to underlying bedrock is variable and depends to large extent upon relief. Elevations range from about 1,000 to 2,500 feet. At the higher levels the Wilkeson parent material is thin and small areas consist of residual soil developed from bedrock.

In vegetative cover and forest management this land is similar to areas of Olympic soil material. Some areas slow in restocking to timber are used to limited extent for grazing cattle.

Salkum silty clay loam, undulating (Se).—This soil is widely distributed in large continuous areas in the west-central part of the county. It occupies undulating to very gently rolling high terraces or bench land, which are remnants of what was once a more extensive plain. Because of its large total area and favorable relief it is one of the more important agricultural soils of the county. It developed on a deep deposit of very strongly weathered gravel and cobblestones embedded in a clay matrix.

The Salkum and associated soils from similar parent material occupy an extensive plain sloping gradually from east to west. North of Salkum, near Burnt Ridge School, the elevation reaches 850 to 900 feet and the plain has the general appearance of a fan that opens at this point and extends southwest to Vader and northwest beyond Chehalis. The slope is gradual and uniformly in a westerly direction to an elevation of about 350 feet near Napavine. Drainage waters also flow to the southwest and northwest, and the main streams occupy former channels of much more extensive postglacial waters. This plain occupies about 6 or 7 townships, and probably one-half of it is occupied by Salkum silty clay loam, undulating.

In its virgin condition, Salkum silty clay loam, undulating, is covered by a partly decomposed dark-brown organic mat 1 or 2 inches thick. Abruptly under this layer and extending to 10 or 12 inches is dark-brown or brown moderately acid silty clay loam, which is a lighter brown or light yellowish brown when dry. This layer is very granular and friable and contains many small rounded shotlike pellets, or concretions, high in content of iron and manganese. In cultivated fields where the organic matter is largely destroyed the exposed soil has a reddish cast or light reddish-brown color.

The surface soil just described grades into yellowish-brown or slightly reddish-brown moderately acid silty clay loam upper subsoil—granular, firm, or slightly compact but permeable—that contains numerous small, rounded shotlike pellets but not so many as the surface soil. At 20 to 24 inches the upper subsoil grades into a slightly more compact silty clay or clay lower subsoil, which is moderately permeable to roots and water. Irregular crumb or granular structural units are highly coated with colloids. Under certain moisture conditions this layer has a distinctly reddish color, but normally, or when dry, it is yellowish brown. The lower subsoil and the parent material, or substratum, which occur at a depth of 34 to 40 inches, are strongly acid.

The parent material, or substratum, extends many feet without much change and is composed of ancient very strongly weathered gravel, cobblestones, and a clay matrix, all probably from alpine

943244—54——3

glacial outwash plain deposits of a much earlier period than the Vashon or even the Admiralty glaciation. The embedded gravel and cobblestones are easily cut through with a spade and break into smooth highly colored clay. Moist or wet fresh cuts through this material give a striking picture of concentric weathering and brilliant coloration of reds, yellows, purples, blues, and many other colors. The whole mass is relatively compact and only very slowly permeable to water. Root penetration is largely restricted. The gravel and cobblestones are from assorted quartz, andesite, basalt, granite, and various quartzites. Resistant quartzites of various colors are scattered through the profile and occasionally on the surface. The layer also contains good collections of agates and, in rare instances, well-preserved pieces of petrified wood.

Use and management.—Salkum silty clay loam, undulating, has a maximum slope of 6 percent. Surface drainage is well established, but internal movement of water is retarded by the compact substratum, which also serves to conserve the moisture supply. Generally the soil can be worked early in spring and is sufficiently drained for early crops in spring and for winter grains. On the lower benches of the Newaukum River valley and next to the hills south of Napavine, some areas have evidently developed in part under more restricted drainage than now exists. The surface soil in these areas has a stronger yellowish-brown color of slightly grayish cast.

This soil was originally heavily forested with Douglas-fir, hemlock, and a few cedar trees. The land has now been logged, but it is gradually restocking to second-growth timber of similar forest types. Logged areas are quickly reclaimed by bracken fern, salal, Oregon grape, fireweed, hazelnut, and other brush and shrubs. Excessive burning has destroyed most of the second-growth timber in the majority of places. Probably less than one-fourth of this area has been cleared and is under cultivation.

Salkum silty clay loam, undulating, is deficient in organic matter and available nitrogen. To keep its fertility at a level high enough for crop production commercial fertilizer, barnyard manure, and crop residues must be applied and rotations containing legumes used. Crops respond well to phosphate fertilizers, but as yet experimental data have not shown appreciable benefits from other commercial fertilizers or lime. An initial application of 300 pounds an acre of superphosphate, or its equivalent, followed by 250 pounds an acre each year is the usual procedure. Mixing the phosphate with barnyard manure gives satisfactory results where early crops are grown. Beneficial in maintaining the nitrogen supply during the early growing season is the practice of applying nitrogen in the form of nitrate of soda or sulfate of ammonia. From 20 to 40 pounds of nitrogen is applied with manure and phosphate, or 60 to 80 pounds alone. The effects of different fertilizer treatments on alfalfa grown in the greenhouse are shown in plate 6, *C*.

The crops—mainly hay, pasture, and small grains—are for the most part those useful to dairying. Oats, grown for both hay and grain, are the most common crop and yield about 1 or 1½ tons of hay an acre or 40 to 60 bushels of grain. Wheat is grown to less extent and

yields about 25 to 35 bushels. Nearly all of the wheat is of winter varieties planted late in September or October and harvested in July. Most of the oats are also winter varieties, but some spring varieties are grown. The winter grains are preferable because they are able to withstand drought early in spring or summer and assure higher yields.

Wheat is sown at the rate of 1½ or 2 bushels to the acre; oats, at the rate of 3 or 4 bushels an acre. If less than these quantities of seed are used the stand is usually poor.

Oats and vetch is a common hay mixture yielding more than double that of oats alone. Red clover is grown to some extent, but stands are difficult to obtain unless particularly well managed. Alfalfa is not well suited and difficult to establish. Grass hay and grass pastures are common; they are composed of a variety of different grasses and legumes. One of the better pasture mixtures recommended by the State Extension Service for the well-drained upland soils (7) is 5 pounds of English ryegrass, 3 pounds of Italian ryegrass, 4 pounds of tall meadow oatgrass, 6 pounds of orchard grass, 2 pounds of Kentucky bluegrass, 1 pound of common white clover, 2 pounds of red clover, and 3 pounds of alsike clover. The use of alta fescue in the mixture is also becoming popular.

Strawberries, an important specialized crop in the county, are nearly all grown on this soil. They are well suited to it, and yield 2 to 3 tons an acre (pl. 5, *A*). This crop is raised principally for canning and freezing.

Minor crops are apples, cherries, raspberries, loganberries, filberts, and some peaches. Apples and cherries are produced in homestead orchards, mostly for home consumption. A small acreage is in pie cherries, but in general cherries are not especially well suited and tend to die after a few years. A few small plantings of the Pacific Gold variety of peaches have been made recently. Filbert production has been increasing, and some of the new orchards are on this soil. The Barcelona is the principal variety; Du Chilly is used as a pollenizer. Filbert production probably will not become extensive, as the trees root deeply and need a deeper soil than this one.

Salkum silty clay loam, deep, nearly level (SA).—From the undulating Salkum silty clay loam this phase differs in depth to compact parent material. Ordinarily its depth to parent material is 4 feet or more, and in the area near Salkum, 6 to 8 feet. Somewhat greater depths may be encountered within short distances. In some areas the first few feet of the parent material consists of a compact variegated clay that does not have any decomposed gravel in the clay matrix. The relief is gently undulating to nearly level, particularly in the area near Salkum, where slopes are 0 to 3 percent. In other parts of the county, the soil occupies tops of gently rolling knolls up to 5 percent in slope.

Where the depth to compact parent materials is less than 4 feet the areas are classified not as this phase but as Salkum silty clay loam, undulating. Also mapped in the undulating phase are areas in which the parent material is so compact that root penetration is restricted to less than 4 feet, even though the gravel-and-clay matrix is well be-

low 4 feet. This compactness of parent material is found in areas between Napavine and Winlock.

Other than in depth to the parent material this deep nearly level soil differs very little from the undulating Salkum silty clay loam. Generally it is redder than is characteristic for the undulating soil. The subsoil is not so compact and, furthermore, the penetration of trees and cereal roots is deeper. This deeper soil is important for deep-rooted crops. Filberts and other crops requiring a deep soil for root penetration can be grown more successfully than on the undulating Salkum silty clay loam.

Salkum silty clay loam, rolling (Sc).—Areas of this soil occupy rolling land (6- to 15-percent slopes) between the nearly level upland plain and the lower valleys and streams.

This soil is similar to Salkum silty clay loam, undulating, except that increased surface drainage and aeration have resulted in the development of stronger colors, especially red. Depth to underlying material is slightly more variable, and partly weathered pebbles and scattered quartzite are more common. The total area is large, but less has been cleared and is being farmed than of the undulating phase. Crops and yields are comparable.

Salkum silty clay loam, rolling, deep (Sd).—Rolling areas (6- to 15-percent slopes) are occupied by this soil, which occurs between Salkum silty clay loam, deep, nearly level, and the rolling Melbourne and Olympic soils. Smaller areas of it are surrounded by the deep, nearly level, Salkum silty clay loam.

This rolling deep soil is relatively similar to the deep, nearly level Salkum silty clay loam. Variations between the two profiles are the same as those found between the undulating and the rolling Salkum silty clay loam soils.

Where this rolling deep soil is adjacent to soils of the Olympic series it is redder and its substratum contains basalt rock. The total area is small. Less of this soil than of the deep nearly level phase has been cleared for farming, but crops and yields are comparable.

Salkum silty clay loam, moderately steep (Sb).—This soil occurs on short moderately steep slopes along drainageways or elongated irregular slopes adjacent to the less sloping areas of the undulating phase. Slopes range from 15 to 30 percent. Surface drainage is more rapid than on the undulating soil, and the subsoil does not become so highly saturated during winter and spring. To minor extent small seep areas occur adjacent to stream channels or in occasional pockets on the slopes.

The profile is more variable than that of the undulating Salkum silty clay loam, and the higher and more exposed points are usually shallower and commonly contain many scattered quartzite fragments or strongly weathered but firm basaltic, andesitic, and in a few places, granitic pebbles and stones. These higher areas have stronger color development, usually being redder.

Use and management.—Salkum silty clay loam, moderately steep, is widely distributed among the Salkum soils, but none, or at least only a very minor part, is cultivated. The moderately steep and irregular relief makes the land unfavorable for cultivated crops, principally be-

cause farm machinery can be used only with difficulty. Although erosion is not a problem in the virgin condition, it might become accelerated under cultivation. Nearly all the areas have been logged, and in most places are slowly restocking to coniferous trees. Competition is keen between coniferous and deciduous trees and brush having no economic importance. In many areas some management and reseeding will be necessary if these lands are to produce profitable timber again. The best use for this soil is forest.

Scamman-Lacamas complex (SF).—This complex consists of areas in which Scamman silty clay loam and Lacamas silt loam are so intricately mixed that separation is not practicable on a map of the scale used. The complex occurs principally in gradation zones between areas of Scamman and Lacamas soils that are large enough to be mapped separately. In these areas the microrelief is gently hummocky. Scamman silty clay loam occupies small knolls a rod or two in diameter and usually a foot or two higher than the general level of the surrounding Lacamas silt loam.

Most of the complex has been logged. It is slowly restocking to timber and brush common to the two member soils or has been seeded to pasture grasses and is used for grazing. Crops and cultural practices are similar to those employed on the two member soils where they occur in longer bodies and are mapped separately.

Scamman silty clay loam (SH).—Developed on the Salkum plain on nearly level relief where surface drainage is slow, this soil occupies a position intermediate between the well-drained Salkum soils and the poorly drained Lacamas and the Kopiah soils. Its parent materials are the same as those of the Salkum soils.

The surface soil, a light-brown or light yellowish-brown silty clay loam, is moderately friable, weakly granular, and contains a few shotlike pellets. It varies in depth. The range is from 10 to 28 inches, but commonly the layer is 12 to 16 inches thick.

The surface layer grades into a 6- or 8-inch layer of light yellowish-brown or yellowish-brown slightly compact but permeable heavy silt loam or silty clay. Some light-gray and slight yellow staining occurs in this new layer; it contains a large quantity of degraded whitish ashy material in its lower part, and rests on a layer of compact and dense clay. This clay, 12 to 16 inches thick, is gray or yellowish gray with yellowish-brown and light-gray mottling. It tends to form a blocky or slightly prismatic structure, which in turn breaks into small, sharply angular fragments. Degraded ashy material coats the surface of cleavage planes and structural units and imparts a variegation of lighter color.

The upper substratum, at a depth of 32 to 48 inches, consists of yellowish-brown or light yellowish-brown dense clay, stained and mottled with rust brown and yellow. This layer grades into the parent material, which is similar to that underlying the Salkum soils but much more highly stained and mottled.

The soil occurs on level or nearly level relief where the water table is close to the surface. Slight changes in elevation are accompanied by changes in drainage relations. Small spotty areas of either better drained or more poorly drained soils are included in places. The

better drained or more poorly drained soils in these places rarely represent more than 10 or 15 percent of any single area and are usually too small and irregular to be separated. Internal drainage is restricted mainly by the dense clay subsoil; surface drainage is slow, although water does not stand for long periods. Late in summer crops are badly damaged by lack of moisture. Their roots cannot penetrate into the subsoil readily, and the capillary upward movement of water is restricted.

Use and management.—Uncleared areas of Scanman silty clay loam support a heavy stand of mixed conifers and deciduous trees and a thick-growing undercover of brush and shrubs. Cedar and hemlock are more common, and the undercover contains, with the other types, more of the moisture-loving plants, as spiraea, wild rose, and willow. Logged areas quickly produce a similar cover.

Early maturing grain and hay crops do fairly well, for the soil is not too wet for planting in winter or early in spring, and moisture conditions are favorable during the growing season. The soil is not adapted to perennials or deep-rooted crops. Some filberts are grown, but the trees die back early. The clover hay grown is mostly a mixture of red, common white, and alsike. Pasture mixtures are usually higher in white and alsike clovers than mixtures seeded on better drained soils. Partly cleared stump lands are commonly seeded to pasture mixtures and used for supplemental grazing. Yields are variable because drainage conditions are unfavorable; they are more assured where the soil is drained to prevent waterlogging early in spring. From 2 to 4 tons of mixed hay and 1 to 1½ tons of oat hay are common yields. Fertilizer requirements correspond to those for the Salkum soils.

Scamman silt loam (SG).—The total area of this soil is small. Its surface texture differs from that of Scamman silty clay loam, and usually it has a browner surface color and is deeper to the dense clay subsoil. Crops, farm practices, and yields correspond closely to those on Scamman silty clay loam. One small area about 1 mile south of Winlock having a much darker surface color is included with this soil.

Schooley loam (SK).—This hydromorphic associate of the Greenwater soils occurs on the low terraces along the upper valley of the Nisqually River. It occupies low swampy land where seepage from the hills has saturated the sands of the substratum and the water table is close to the surface.

The surface 8 or 10 inches is moderately acid dark to very dark brownish-gray highly organic loam having a smooth silty feel and slightly granular mellow structure. This is underlain abruptly by a 4- to 6-inch layer of dark-gray and gray pepper-and-salt sand containing a large quantity of small yellowish pumice and some iron mottling. This sand layer is, in turn, underlain by light-gray pepper-and-salt sand that is strongly mottled and stained with small concentrations of softly cemented iron. At depths ranging from 3½ to 8 feet lies a very slightly acid light brownish-gray heavy clay, mottled with blue and containing rust-brown iron concentrations in the form of small lumps.

Use and management.—Schooley loam is very swampy. Drainage is necessary before it can be used. Probably less than 40 acres have been cleared and drained. The soil is used principally for pasture, but a small part is planted to spring oats. Even where drained the soil remains fairly moist. It is excellent for Reed canarygrass, which is used mainly for pasture but also cut for hay. The grass is of good quality if cut before it gets too old and coarse. As this soil is associated with the more droughty Greenwater soils, it is much prized for the pasture and hay it produces. Most of the land is covered by a heavy second-growth mixture of conifers and deciduous trees, brush, and shrubs and by a ground cover of sedges, skunkcabbage, wild rose, spiraea, and water-tolerant grasses.

Schooley silt loam (SL).—Nearly level poorly drained areas associated with the Siler soils are occupied by this soil. Like the Siler, it is characterized by a layer of pumice in its profile.

The surface 10 or 12 inches is light brownish-gray or grayish-brown smooth mellow silt loam, and underlying that, a 2- to 8-inch layer of lighter colored silt loam mottled with rust brown and yellowish brown. A layer of loose and porous pumice 5 to 10 inches thick occurs within 12 or 16 inches of the surface or occasionally deeper. The pumice fragments are 1 to 5 millimeters in diameter and have a whitish slightly yellow-stained color. A very thin layer of fine-textured pumice commonly occurs between the surface soil and the open, coarse pumice layer. Evidently this thin layer was deposited in slowly moving water. The coarse pumice layer is underlain by light yellowish-brown silty clay or silty clay loam having a cheesy consistence and strongly mottled rust-brown spots. The subsoil, especially the lower part, is stratified with fine sand, silt, and clay.

Included with this soil in mapping is an area of about 20 acres just east of Packwood and another of 15 or 20 acres along the upper part of Siler Creek. In both of these areas the surface soil contains a large quantity of pumice, and stratifications of fine and coarse sediments and peat lenses underlie the loose pumice layer, which ranges from 6 to 24 inches thick.

Use and management.—The nearly level relief and low position of Schooley silt loam restrict surface drainage, and internal drainage is impeded by the high water table. The soil remains saturated during winter and far into spring. Drainage is necessary before cultivated crops can be grown. Open-ditch drains are fairly successful where an outlet can be made that will permit rapid lateral movement of water through the pumice layer.

More than half the soil is cleared and used, principally for permanent pasture (pl. 5, *B*). A few of the better drained areas are cropped to alsike clover and ryegrass, oats and vetch, or oats and peas for hay. Yields are high. Permanent pastures on the better drained areas include clover and grass mixtures. On the wetter areas Reed canarygrass is commonly grown and produces a luxuriant stand of high carrying capacity.

During prolonged dry spells the surface soil becomes dry and hard, and shallow-rooted crops, which do not penetrate the pumice layer, are severely damaged. The subsoil remains very damp, but upward capillary movement of water through the pumice is restricted. In a

few areas this restriction of capillary movement has been alleviated to some extent by a system of irrigation whereby water moves laterally through the pumice layer rather than over the surface. Uncleared areas are marshy and support a dense cover of deciduous trees, brush, shrubs, and bunches of sedges and coarse grass.

Siler fine sandy loam (SM).—This soil—closely associated with Siler silt loam—is characterized by a 6- to 14-inch layer of light grayish-brown mellow friable fine sandy loam that rests upon a 4- to 10-inch layer of loose porous yellowish-white pumice. The pumice layer overlies stratified fine sandy loam, fine or very fine sand, and occasional lenses of silt.

The depth and distribution of the pumice stratum is more complex in this soil than in Siler silt loam, especially in the area near Cora Bridge. Where the surface soil was only 6 or 8 inches deep, plowing often mixed the surface soil with the underlying pumice. Because of this, areas that originally had a silt loam surface soil have been included. Also included are a few areas in which the pumice layer was originally on the surface but has since become mixed with the surface layer by tillage. A few areas adjacent to the stream are relatively free from pumice.

Use and management.—Some attempts have been made to mix the surface layer of this soil with the underlying pumice material by deep plowing. The purpose of this was to eliminate the droughty effect caused by the pumice layer, which prevents capillary movement of moisture. These attempts have rarely been successful, mainly because the pumice is too deep, but partly because it will not stay on top. It rapidly slides back into the plow furrow.

This soil is fertile and productive. Crops are similar to those produced on Siler silt loam. Nearly all areas have been cleared and are farmed. Yields compare favorably with those on Siler silt loam, but over a long period of time they will average slightly less because this sandy loam soil has lower moisture-holding capacity.

Siler silt loam (SN).—This well-drained recent alluvial soil occurs on fairly level or gently undulating relief 10 to 20 feet above the normal stage of the Cowlitz River. Occasionally the greater part of the valley is flooded, but ordinarily the relief is great enough for adequate surface drainage. Internal drainage is moderate. The soil is derived from materials similar to those of Puyallup soils, but it occurs in the pumice belt and has one or more layers of light-colored pumice fragments 1 to 5 millimeters in diameter in its profile. This soil occurs only in this one area.

The surface soil, 6 to 18 inches thick, consists of light grayish-brown or olive-gray-brown, mellow and friable silt loam that occasionally contains some light-gray pumice fragments. The surface soil rests abruptly upon a 4- to 8-inch layer of loose, porous, yellowish-white pumice, the particles of which are 1 to 5 millimeters in diameter. Abruptly under the pumice is pale yellowish-brown smooth and friable silt loam. At depths of 24 to 32 inches lies a pale yellowish-brown lower subsoil, followed by layers of stratified fine sandy loam, fine sand, and silt that continues for several feet without appreciable change. Some faint mottlings of rust brown and lighter gray may occur in the lower part.

Use and management.—Nearly all Siler silt loam has been cleared and cropped to hay, grain, and pasture grasses. It is very fertile and productive. Hay crops and permanent pasture plants able to root through the pumice layers do best. Where the surface soil is less than 10 or 12 inches deep, shallow-rooted crops often suffer severely from lack of moisture. The pumice layer restricts penetration of roots and capillary upward movement of moisture; therefore the surface soil tends to dry quickly. In a few areas this droughtiness is alleviated by a type of flood irrigation in which the water flows horizontally through the pumice layer.

Alfalfa, cut twice during the season, yields 4 to 6 tons an acre; the third crop is commonly pastured. Grass hay, including clover mixed with ryegrass or timothy, produces 3 to 4 tons. Oats and Austrian peas sown together in fall yield 3 to 4 tons an acre. Red, white, and alsike clovers, English and Italian ryegrasses, timothy, Kentucky bluegrass, alta fescue, and orchard grass used for permanent pasture give excellent yields.

Except for application of barnyard manure, which is available in adequate quantities, little fertilization is practiced. Clover in pasture and hay mixtures help replenish the nitrogen supply.

Snohomish silt loam, pumicy (So).—This phase occurs in the area of pumice fall. It differs from Snohomish silty clay loam in three principal respects: (1) The most important difference is a layer of pumice that separates the mineral surface from the underlying peat; (2) the surface soil is a deposit of silty materials originating from mountain glaciers and resembles the surface of Puget silt loam; and (3) the surface soil is also a silt loam rather than a silty clay loam.

The surface soil is grayish-brown silt loam highly mottled with rust brown. It is mellow, light, friable, and 4 to 12 inches deep. An 8- to 14-inch layer of yellow and light-gray pumice occurs under the surface soil and rests upon brown peat. This pumice contains relatively uniform particles the size of coarse sand and is very loose and porous. The underlying peat is dominantly woody, but mixtures of sedge and colloidal peats are common.

Included are small spotty areas that have a surface soil shallow enough to become mixed with the pumice upon cultivation. This mixing gives the surface soil a gritty loam or pumicy sandy loam texture, depending upon the degree of mixing that has occurred.

Use and management.—Snohomish silt loam, pumicy, is swampy and must be drained before it can be used. As for the Schooley soils and Rifle peat, pumicy, the surface soil is subject to severe drying during exceptional dry summers, and crops are damaged by lack of moisture. Much of the area is covered by sedges and water-tolerant grass. Some drained areas have been cleared and used for hay or pasture. The soil is fertile and produces good yields. Cropping practices are much the same as on Schooley soils; yields probably average higher. Reed canarygrass produces a luxuriant growth and is the most common pasture grass. The native cover—similar to that on other poorly drained soils—consists of sedges, willow, alder, maple, snowberry, wild rose, and spiraea.

Snohomish silty clay loam (Sp).—This inextensive soil usually borders small stream channels in association with Rifle peat or Car-

bondale muck. In the few areas mapped, it consists of a shallow layer of mineral soil resembling Wapato silty clay loam over peat. The surface soil, a grayish-brown granular and friable silty clay loam, grades into moderately compact highly mottled clay. At 8 to 24 inches the clay layer rests upon dark-brown woody or sedge peat that usually contains mixtures of colloidal peat and lenses of silty mineral material. The peat substratum usually extends to 6 feet or more.

The soil is variable. In many places mixtures of peat in the surface soil give a peculiar mucklike appearance. Several small areas that have a silt loam surface are included.

Use and management.—Vegetative cover and farm practices are similar to those on the organic soils. Nearly all of the soil is in permanent pasture; only a few areas are cropped to hay and grains. This soil is less deficient in minerals than the peat soils, however, and for this reason farmers value it more highly for permanent pasture.

Spanaway gravelly sandy loam (Sr).—This very dark-colored prairie soil developed on smooth glacial outwash plains or tops of broad terraces under a cover of grass and herbs; it is the most extensive of the soils occupying the outwash plain of the last continental, or Vashon, glaciation.

The surface soil, 10 to 14 inches thick, is very dark grayish-brown or nearly black sooty gravelly sandy loam. This layer grades into 8 or 10 inches of yellowish-brown or pale-brown gravelly sandy loam, somewhat darker at the top. The gravel in this gravelly sandy loam has some clay coating and rusty-brown stains. At a depth of 20 to 26 inches the gravelly sandy loam rests upon a substratum of poorly assorted stratified gravel and sand of grayish washed appearance. Stones are common in the substratum and frequently occur all the way to the surface.

Use and management.—Spanaway gravelly sandy loam has developed under an open herb-and-grass cover. Some fir and pine trees are coming in, but they are stunted, limby, and of poor quality. Clumps of Oregon oak commonly occur in places.

The soil is not difficult to clear but is porous, droughty, and low in fertility; hence, only a small part is farmed. Productivity increases in the few places that can be irrigated, but large quantities of fertilizer are necessary for satisfactory returns. The supply of organic matter is high, but it is largely inert and therefore not particularly beneficial to plant growth. Proximity to Centralia increases the value of this soil for small homesites and chicken and turkey farms.

Sultan silt loam (Ss).—Smooth recent flood plains are occupied by this soil. It occurs in a position intermediate between the Puyallup soils and the poorly drained Puget soils. It is derived from silty sediments similar in origin to those of the Puyallup soils.

The surface soil, extending to 10 or 12 inches, is grayish-brown or grayish-olive-brown silt loam, smooth, mellow, softly granular, friable, and slightly acid. This layer grades into pale yellowish-brown or grayish-brown friable silt loam, which has a soft crumb or irregular granular structure and shows a slight to moderate amount of yellow, rust-brown, and light-gray mottling. Below 24 inches and on down to

about 40 inches the subsoil is firm and less mottled. At about 40 inches it grades into pale yellowish-brown mellow silty clay loam, faintly mottled with rust brown and lighter gray. Stratified fine sand, silt, and clay are common in the lower subsoil and substratum.

Use and management.—Inasmuch as Sultan silt loam occupies fairly level relief in somewhat back-bottom positions, surface drainage is fair to good and internal drainage is slow but not restricted. In most places, therefore, drainage is not necessary for crop production. Where it must be drained, the soil has sufficient slope for open-ditch drains. The places needing drainage have a subsoil that is commonly more mottled. Only during occasional years do floodwaters overflow this soil.

Most of the soil is farmed in association with dairying. Hay, permanent pasture, and small grains are the principal crops. Land use and management practices are similar to those on Puyallup silt loam. Slower subdrainage, and resulting increase in moisture-holding capacity, usually bring higher yields on this soil than on the Puyallup, and permanent pasture is also better through the dry season. The soil is inherently fertile and productive, but under cultivation organic matter and nitrogen must be maintained by using barnyard manures or legumes. The soil also responds to phosphate fertilizer.

Tower silty clay loam (TA).—Swampy depressions in the Salkum plain are occupied by this soil. From soils of the Lacamas series it differs principally in having darker surface soil, and from those of the Kopiah series it differs in being darker and in having a more dense and compact clay subsoil.

A typical area of Tower silty clay loam is most extensively developed 3 or 4 miles southeast of Winlock, where it is associated with the Lacamas and Kopiah soils. Numerous other areas are scattered throughout the central part of the county on level or nearly level swampy depressions or along narrow drainageways in the Salkum plain.

A representative profile has a dark or very dark brownish-gray heavy silty clay loam or light clay surface soil 8 to 12 inches thick. This layer—granular, fairly friable, and relatively high in organic matter—overlies an upper subsoil layer of light olive-gray stiff and compact clay of blocky or slightly columnar structure. The upper part of this subsoil is a 1- or 2-inch irregular layer of light-gray to nearly white ashy silt loam from which streaks or "fingers" extend downward for several inches. At 16 to 20 inches the upper subsoil grades into a yellowish-gray or greenish-gray stiff dense clay lower subsoil. The lower subsoil is slightly mottled and stained with yellow, rust-brown, and green. Its faint blocky structure breaks into irregular fragments highly coated with colloids. The lower subsoil rests on highly weathered and stained parent material, which occurs at depths below 3 feet and is similar to the material underlying Lacamas soils.

In color and texture the surface soil and subsoil vary. Some small areas are mucky and deep; others are only slightly darker than the soils of the Kopiah series.

Two areas totaling about 40 acres that have a silt loam surface soil are also included. The largest one occurs about a mile northwest of

Salkum. In this the profile may be typical in one place, but within a few feet, consist of a very sooty and highly organic surface soil over highly iron-stained sandy subsoil. Between Meskill and Dryad on the north side of the Chehahs River is a small area of soil that has a lighter colored less organic surface soil and a more permeable gritty clay subsoil.

Use and management.—Tower silty clay loam must be drained before it can be used for cultivated crops, but this is difficult because the clay subsoil is compact. Many parallel shallow lateral ditches connected to a central ditch are usually dug to carry off excess surface water.

Little of this soil has been cleared or is being used. Most of the land has been logged and has grown up to a thick cover of cedar, ash, maple, willow, and a heavier undercover of brush and shrubs, including wild rose, spiraea, dogwood, vine maple, evergreen blackberry, and numerous sedges and water-tolerant grasses. The few areas cleared and drained are fertile but difficult to work. This soil is more productive than either the Kopiah or Lacamas soils because it contains more organic matter, but it is usually more difficult to drain. Although crops are similar to those grown on Lacamas silty clam loam, yields are slightly higher.

Vader loam, hilly (VA).—Softly compacted sandstone is the material from which this soil developed. It occupies hilly land.

A typical profile in the virgin state has a 1- to 2-inch organic mat of partly decomposed forest litter at the surface. Abruptly under this mat lies an 8- or 10-inch layer of brown or dark yellowish-brown gritty loam, friable and granular in structure and high in content of shotlike pellets. The surfaces of the granules are darker than the insides. Some of the shot are relatively large.

Beneath the surface soil and continuing to a depth of 20 or 24 inches, is the upper subsoil—a lighter brown or yellowish-brown slightly granular friable gritty loam having a high sand content and many rounded shotlike pellets. This layer is firm in place but easily crushed into fine particles when removed. It has many root channels and areas of darker brown staining. The lower subsoil, extending down to a depth of 3 to 3½ feet, is yellowish-brown strongly weathered sandstone. The sand particles are easily crushed into single grains having a smooth silty feel. This lower subsoil is firm in place but easily breaks into large lumps and thence into single grains. Many of the root channels have dark organic staining and areas of reddish, yellowish, and darker brown discoloration.

The parent material consists of yellow or orange-brown, weathered, interbedded and cross-bedded sandstone. It is fairly easy to cut with a spade and can be broken into single grains. The sand in the lower subsoil and parent material contains many micaceous particles and is so weathered that it is smooth when rubbed between the fingers.

The soil is variable; gradations between it and Melbourne soils are common. In places a thin layer of shale overlaps the underlying sandstone. The overlapping produces a soil that to a depth of about 2 feet is very similar to Melbourne soils. These overlap areas are variable and scattered throughout the typical soil in an intricate pat-

tern. In many places the soils in a road cut on one side of the road are typical, whereas those on the opposite side have a surface soil and subsoil made up entirely from shale material. Boundaries were difficult to locate, and some the Melbourne soils surrounding this area probably contain bodies of Vader loam, hilly. An area of about 80 to 100 acres next to a cemetery 1 mile northeast of Doty has a sandy loam surface soil and slopes of 5 to 15 percent.

Use and management.—Vader loam, hilly, is made up of hilly land unsuited to any kind of farming. Originally it had a forest cover, but since it was logged it is only very slowly restocking. The soil is very erosive and erodes readily if the heavy cover is disturbed or destroyed. Small spots of bare sandstone are common along stream gullies and on the steeper slopes. Grazing on this soil would probably result in accelerated erosion. The land is suited only to forest and efforts should be made to reseed and protect the cover.

Wapato silty clay loam (Wd).—This soil is widely distributed in stream and river valleys in the western part of the county. It is associated with the Chehalis soils and occupies back-bottom or relatively level imperfectly drained positions. It is derived from shale, sandstone, and basalt materials similar to those of Chehalis soils. Areas are large and fairly uniform in main valleys. In many of the smaller tributary valleys consisting principally of Wapato soils, this soil may vary somewhat in color and profile characteristics.

The surface soil is grayish-brown or brownish-gray granular silty clay loam. Rusty or yellowish-brown mottling almost reaches the surface in some places but is usually below 8 or 10 inches, where the surface soil grades into an upper subsoil. The upper subsoil is brownish-gray clay very highly mottled or spotted with rust brown and yellow. It has a distinct granular or interlocking crumb structure and is only slightly compact. The lower subsoil—beginning below 24 to 28 inches—is light olive-gray moderately tight plastic clay. It is not so strongly mottled and spotted with rust brown and yellow as the upper subsoil. As depth increases the material is less granular and of slightly bluish cast. Some of the substratum materials are stratified, and in a few places the subsoil is stratified. A few areas have brown shallow surface soil underlain by highly mottled gray subsoil.

Use and management.—Nearly all the timber on Wapato silty clay loam has been cut. Much of the land has been cleared for cultivated crops and pasture. Uncleared areas support Douglas-fir, cedar, and hemlock; heavy growths of maple, alder, ash; brush and shrubs, including wild rose, spiraea, willow, blackberry; and spotted clumps of sedges. This growth is difficult to penetrate, and the land affords little grazing unless partly cleared.

The soil is low-lying and therefore has slow surface drainage. Internal drainage is restricted by the heavy clay subsoil. Excess surface water has to be drained away before cultivated crops can be grown successfully. The soil remains wet and cold longer in spring than do Chehalis soils. In drier years, however, the added moisture supply is beneficial in summer, and crop yields may be higher than on the Chehalis soils.

The principal crops are wheat, oats, hay, and pasture. Wheat yields 20 to 50 bushels; oats, 40 to 100 bushels; and ryegrass mixed with red and alsike clover, 1½ to 4 tons of hay, depending upon moisture conditions. Crops are not assured every year, and near failures are not uncommon. Permanent pasture does well and affords grazing through summer in all but the drier years. Mixtures used for pasture are usually similar to those for hay, but yields are sometimes increased by adding orchard grass and Kentucky bluegrass. In the wetter areas Reed canarygrass does fairly well.

The soil is fairly fertile. The principal limitation is its saturation with water during winter and the late date at which crops planted on it mature. The principal fertilizer treatment is yearly applications of 5 to 6 tons of barnyard manure an acre.

Wapato silt loam (Wc).—Although less extensive than Wapato silty clay loam, this soil is as widely distributed throughout the western part of the county. It is closely associated with Wapato silty clay loam but usually occupies slightly higher positions having slightly better surface drainage. The principal feature distinguishing this soil from Wapato silty clay loam is the silt loam surface soil, which is granular in structure and slightly more friable than that of the silty clay loam.

A large part of this soil is cleared for cultivated crops and pasture. Yields, crops, and conditions are very similar to those on Wapato silty clay loam.

Wapato-Chehalis silty clay loams (Wa).—This complex of Wapato silty clay loam and Chehalis silty clay loam occurs in a few small areas. Because of the impenetrability of the areas and the intricate pattern of distribution, separation of the two soils is not feasible. All of the area is heavily timbered with the kinds of trees that commonly grow on the two soils where mapped separately.

Wapato-Galvin complex (Wb).—In the upper parts of some of the smaller valleys the Wapato and Galvin soils occur together. It was impossible to separate them on the map because they occurred in such intricate pattern and were inaccessible. The areas consist of Galvin loam, Wapato silt loam, and Wapato silty clay loam. All of the complex has a second-growth cover of coniferous and deciduous trees, shrubs, and brush.

Wilkeson silt loam, rolling (Wf).—This soil occupies rolling terrain at the lower extremities of the mountainous land in the northeastern part of the county. Wilkesonlike soils occur in large areas of mountainous country in this section and northward into Pierce County.

Under virgin conditions a 1- or 2-inch layer of partly decomposed organic duff is at the surface. Mineral surface soil, extending to a depth of 15 or 18 inches, is brown moderately acid silt loam containing many small, soft, spherical, shotlike pellets. It is friable and has a mealy feel.

The upper subsoil, continuing to a depth of 30 to 36 inches, is yellowish-brown gritty loam or clay loam that contains numerous small shot. This layer is firm but easily broken into small soft irregular

fragments and is relatively mellow when wet. The lower subsoil is a lighter yellow silty clay with some faint yellow mottling and spots of light gray. It is slightly compact but easily breaks into a soft crumb structure. Small weathered pumice fragments give it a variegated appearance.

After a gradual transition the lower subsoil overlies by a substratum of light yellowish-brown or yellowish-brown silty clay. Under this layer remnants of a cemented gravelly till may occur in places throughout the area.

Angular and subangular gravel, stones, and occasional boulders are commonly scattered on the surface and throughout the solum. These rock fragments are dominantly of basic igneous character, but granitic boulders occur in places.

Use and management.—Wilkeson silt loam, rolling, occurs at 1,200 to nearly 2,500 feet elevation. The growing season is shorter and precipitation is higher than where the Cinebar soils are developed. The soil is older, more compact, more strongly acid, and yellower than the Cinebar soils, but in other respects similar. The parent material appears to be derived from fine-grained pumice that has been modified by glacial action. This silty material is similar to that occurring in the Cinebar soils.

Very little of Wilkeson silt loam, rolling, is farmed. It occurs mostly in the more remote parts of the county where logging is the principal industry (pl. 5, *C*). Small subsistence farms in the few cleared areas produce a few cows and chickens and garden vegetables for their owners.

As in the Cinebar soils, organic matter and available nitrogen are deficient and the soil must be fertilized for successful crop production. Crops respond favorably to phosphate fertilizer applied with manure or some other source of nitrogen. Although the high acidity of the soil indicates a deficiency of lime, applications of lime have not, as yet, produced satisfactory results. The soil is suited primarily to forest; it restocks well, principally to Douglas-fir.

Wilkeson silt loam, hilly (WE).—This soil occurs in a few small hilly or irregular areas. In position it is intermediate between the rolling Wilkeson silt loam and mountainous land. Slopes usually range from 15 to 30 percent. Commonly this soil is more gravelly and stony and shallower than the rolling Wilkeson silt loam; it is otherwise similar. Surface drainage is more rapid, but erosion is well controlled by native cover. The relief is unfavorable for agriculture, and the principal use is for forest.

Winlock silty clay loam, gently undulating (WH).—This soil occurs on gently undulating relief (2 to 5 percent). It developed from the same parent material as the Salkum soils and on the same plain, but under a prairie vegetation of grass, fern, and scattered oaks. Its surface soil and upper subsoil are free of shot and much darker than those of the Salkum soils.

The surface soil, extending to a depth of 12 or 18 inches, is dark-brown friable silty clay loam. It is less granular than the surface soil of Salkum silty clay loam, undulating, and does not contain any shotlike pellets. The surface layer grades into a slightly com-

pact but fairly permeable brown or slightly reddish-brown clay. This clay is of coarsely granular or fragmental structure. The surfaces of the fragments are fairly shiny, owing to a colloidal coating, and darker than the interiors. At a depth of 32 to 38 inches, this clay rests abruptly on the typical Salkum substratum—a highly colored and strongly weathered mixture of clay and gravel.

Use and management.—Surface drainage of Winlock silty clay loam, gently undulating, is well established, but internal water movement is slow because the underlying material is compact. Nonetheless, drainage is sufficient to prevent waterlogging. Although conditions are favorable for forest, only grass, fern, and scattered oak persist. Principally because of this grass cover, but also because of its natural fertility, this prairie soil was among the first to be settled. Farming on some areas of the Cowlitz Prairie dates back to the 1830's.

In its virgin state the soil was naturally fertile and high in organic matter, but continuous cropping has depleted the supply of plant nutrients. All areas have been heavily cropped to grain for many years and some for as long as 100 years. Originally 60 to 70 bushels of oats an acre were produced, but yields have slowly decreased. Now some of the older areas produce only 15 to 25 bushels.

Organic matter and nitrogen should be added by applying barnyard manure, plowing under crop residues, or using legumes in crop rotation. A system of crop rotation that includes legumes and careful management will be necessary in most places to restore this soil to its former productivity. Crops respond if 250 to 300 pounds an acre of superphosphate, or its equivalent, is applied with manure or other types of nitrogen fertilizer. Other fertilizers or amendments have not brought such good response. On the whole, however, this soil responds to good management and can be restored to a high productive level, even though it is now depleted of nutrients.

The principal crop is oats threshed for grain. Some wheat is grown, and yields depend to a large extent on the way the soil has been previously cropped. Strawberries, filberts, and other crops yield about as they do on Salkum silty clay loam, undulating.

Winlock silty clay loam, sloping (WL).—Relief is the principal difference between this and gently undulating Winlock silty clay loam. This soil occupies narrow elongated strips between two terrace levels of the gently undulating soil. Slopes range from 5 to 15 percent. Other than in relief, this soil is very similar to Winlock silty clay loam, gently undulating. Crops grown, yields obtained, and farm practices employed are much the same on both soils.

Winlock silty clay loam, level (WK).—In association with the gently undulating Winlock silty clay loam, this soil occupies very gently undulating to nearly level land where surface drainage is partly restricted.

The 10- or 12-inch surface soil is dark grayish-brown silty clay loam that is moderately granular but tends to pack and form small hard clods. The upper subsoil is yellowish-brown or yellowish-gray slightly compact clay loam. At depths of 18 to 30 inches it grades into a lower subsoil mottled with rust brown, yellowish brown, and

light gray. This layer is slightly more compact and heavier than the upper subsoil. Below 3 feet lies a highly colored and strongly weathered layer of clay and softened gravel similar to that underlying soils of the Salkum series.

The profile of this soil is more variable than that of other Winlock soils. Slight changes in the relief affect drainage and bring corresponding changes in the depth, compactness, and degree of mottling in the subsoil. On the more nearly level areas the subsoil is relatively gray, heavy, and compact; whereas on slightly undulating relief and on the knolls the characteristics of the soil profile approach those of the gently undulating Winlock silty clay loam.

Use and management.—The first farms in the State included areas of Winlock silty clay loam, level. Most of this soil has been used or cropped for nearly 100 years. For the last 20 or 30 years at least it has been cropped almost continuously to oats. During that time the organic matter has become depleted and available plant nutrients have decreased. Originally yields were more than 60 bushels an acre, now they are 15 to 25 bushels. Much of the original productivity could be restored by using a crop rotation that includes both legumes and green-manure crops and by applying barnyard manure to increase the organic-matter content and nitrogen supply. Additions of phosphate fertilizer, generally 250 to 300 pounds an acre, have also proved beneficial. Usually some form of nitrogen fertilizer can be used with satisfactory results.

Because of the more gentle relief and partly restricted drainage, field work is usually more delayed in spring than on the better drained soils. The greater moisture held available to plants during the dry season is beneficial, however, and crops are better able to withstand summer droughts. Nevertheless, the soil is less fertile than the other Winlock soils and must be fertilized to produce high yields. Pasture grasses receive moisture later into summer and yield higher than on Winlock silty clay loam, gently undulating. Other crops and cultural practices are similar on the two soils.

Winlock silt loam, gently undulating (WG).—This soil has gently undulating relief and developed under a prairie vegetation of grass, fern, and scattered oak. Its parent materials are similar to those of the Salkum series. It occurs on the lower bench level of the Newaukum valley glacial channel. After the Salkum soil material was deposited, the material in this channel was reworked by postglacial stream waters and much more recently was flooded. The lower bench level formed when outwash of the Vashon glaciation period dammed the outlet to the Chehalis River, and, as a result, nearly all the soils of these reworked terraces along the Newaukum valley have developed under imperfect drainage. Winlock silt loam, gently undulating, however, was more quickly drained and has since developed under relatively free drainage. It is in a more youthful stage of development than the Winlock silty clay loam soils and its substratum is less compact.

The surface soil, a dark-brown friable silt loam 14 to 18 inches deep, grades into a softly compacted brown or reddish-brown softly granular silty clay loam subsoil. At 3½ to 4 feet the subsoil grades into compact parent material of highly weathered clay and gravel.

The surface soil is more friable and easier to work, the subsoil is less compact, and the solum averages 1 or 2 feet deeper than in Winlock silty clay loam, gently undulating.

Use and management.—Winlock silt loam, gently undulating, produces the same crops as Winlock silty clay loam, gently undulating, but yields are usually higher. The soil responds to good management, but like others in the same general area, is deficient in organic matter and nitrogen. Cultural practices are similar to those used on Winlock silty clay loam, gently undulating.

Winston gravelly loam, gently undulating (Wm).—Areas of this soil are widely distributed throughout the county on undulating terraces of the major streams. The soil is associated to some extent with the Olequa soils but usually occupies a lower and more youthful terrace position. Unlike the Olequa soils it has gravel scattered throughout the surface and subsoil and an open gravelly substratum.

In virgin areas the surface is covered by a partly decomposed 1- or 2-inch layer of organic matter, and the upper 4 or 5 inches of mineral soil are dark brown or brown. On cultivation the organic matter is largely lost, and the surface soil to a depth of 10 or 12 inches becomes slightly granular and friable brown gravelly loam that contains a few scattered shotlike pellets and many rounded pebbles. This material grades into a 12- or 16-inch upper subsoil of brown or yellowish-brown friable gravelly loam, which in turn grades into a yellowish-brown gravelly sandy loam lower subsoil that is fairly loose and high in gravel. At 2½ to 3 feet the lower subsoil rests on a very gravelly and sandy layer that is fairly loose and porous.

The pebbles in this soil are slightly stained with rust brown and yellow. They are well rounded and of mixed origin but predominantly of basic igneous character. The interstitial material is mixed gray, yellow, and light-gray fine and coarse sand of pepper-and-salt appearance. Some stratification is evident in the lower substratum.

Soils showing minor variations in parent materials, color, and surface soil texture are included in this one. The parent material of these is dominantly of mixed basic igneous and sedimentary origin and derived principally from eroded Olympic and Melbourne soils. Nonetheless, the parent materials of included soils along the Cowlitz River and in the eastern part of the county contain some admixture of acid igneous materials. Along the upper Tilton and Cowlitz Rivers are included soils having a stronger yellowish-brown subsoil but not the slight reddish cast of those areas derived more dominantly from basaltic materials. The gravel content and surface texture change frequently within short distances. There is some variation in this soil as in other Winston types.

Use and management.—Winston gravelly loam, gently undulating, is not of particular agricultural importance, the principal limiting factors are excessive permeability and low water-holding capacity. Crops are severely damaged during the dry season, and unless rains in spring and early in summer are adequate, yields are low. Only a small part of this soil has been cleared and cultivated. Most of the land has been logged and is now in second-growth timber and brush. Douglas-fir, very adaptable to varying conditions and able to withstand much drought, is the dominant conifer. The principal crops

are hay, grain, and pasture. A few small areas are in strawberries. Organic matter and nitrogen must be added for successful production. General farm practices are similar to those on the Olequa soils.

Winston loam, gently undulating (WN).—This soil is closely associated with Winston gravelly sandy loam, gently undulating, occupies similar terrace positions, and is derived from similar parent materials. It is as widely distributed and has a relatively large aggregate area, though individual areas are relatively small. It differs from Winston gravelly loam, gently undulating, principally in the quantity of gravel in its surface soil and subsoil.

The surface soil, extending to a depth of 8 to 12 inches, is brown or dark-brown friable loam or gritty loam containing a few scattered gravelstones and shotlike pellets. This layer grades into yellowish-brown friable loam upper subsoil. The lower subsoil at 2½ to 3½ feet rests on a very gravelly substratum. This substratum is similar to that underlying Winston gravelly loam, gently undulating, but usually contains more interstitial soil material in the upper foot or two.

Some rounded gravelstones, mainly of basic igneous origin, are scattered throughout the solum. Included are two or three scattered areas totaling 300 to 400 acres that have a sandy loam surface soil.

Use and management.—Under average conditions Winston loam, gently undulating, is droughty but less so than other Winston soils. Under favorable moisture conditions it is suitable for cultivated crops. Only a small acreage has been cleared and used. The soil produces fair yields of hay, small grains, and pasture grass. It is fairly fertile but deficient in organic matter and available nitrogen. Management used and crops raised are similar to those on the Olequa soils, but yields are lower.

Winston gravelly sandy loam, gently undulating (WO).—This soil is less extensive than Winston gravelly loam, gently undulating, or Winston loam, gently undulating, but its areas are as widely distributed. In parent material, position, and variation it is similar to Winston gravelly loam, gently undulating. It differs from that soil principally in having lighter surface soil and subsoil texture and a more porous and open subsoil. It also averages 6 to 10 inches shallower to the gravelly porous substratum.

Use and management.—Very little of this soil is farmed. Drought resistance is low, and crops are severely damaged during the dry season. Nearly all areas have been logged and are in second-growth timber and brush. Farm practices and crops are similar to those on Winston gravelly loam, gently undulating, but yields are lower. The soil is best suited to forest.

Winston gravelly sandy loam, sloping (WR).—This soil occupies a few small areas. It is similar to the gently undulating Winston gravelly sandy loam, but usually occupies areas along drainageways or between terrace levels where the slopes range from 5 to 15 percent. Included with this soil because of small extent and relative unimportance are areas of soil with sandy loam and loam textures.

Winston gravelly sandy loam, moderately steep. (WP).—This inextensive soil occurs in a few small isolated areas. It usually occu-

pies breaks along stream channels or breaks along narrow moderately steep slopes between terrace levels. Slopes are more than 15 percent. Except for steeper relief, the soil is similar to the gently undulating Winston gravelly sandy loam. Unfavorable relief makes the soil suitable only for forest. Included in mapping is a small area southeast of Vader having a gravelly loam surface soil and two areas, less than 10 acres in each, of steeply sloping Onalaska soil southeast of Toledo.

Winston silt loam, nearly level (Ws).—Many relatively small areas of this soil are widely scattered throughout the county in association with the other Winston soils.

There are a few gravelstones in the surface soil and upper subsoil, but the gravelly substratum is similar to that underlying other Winston soils. The surface soil is brown friable silt loam containing a few scattered shot and grading into yellowish-brown silt loam or loam subsoil at a depth of 8 to 12 inches. The subsoil becomes lighter textured with depth and rests on yellowish-brown gravelly sandy substratum at 28 to 36 inches. The parent material is largely of mixed basic igneous and sedimentary origin. In places the soil has a slightly reddish cast.

Only a few areas have been cleared for cultivated crops. All of the areas have been logged and are mostly covered with stumps, brush, and second-growth timber. Crops, yields, and farm practices correspond closely to those on Winston loam, gently undulating.

USE AND MANAGEMENT

The soils in Lewis County are used for two main purposes—agriculture and forestry. Nearly all the soils with relief that will allow normal tillage operations can be considered agricultural or potentially agricultural. The rest probably should be considered primarily forest land.

About 20 percent of the county has slopes gentle enough for cultivation of crops, and of this only a minor part consists of soils not physically suited to crops. The physical characteristics of the soils were given some consideration when areas were cleared for farming, but considerable acreages of soils potentially suited to crops remain uncleared. Probably less than one-third of the agricultural soils in the county are now in cultivated crops or pasture.

MANAGEMENT BY MAJOR SOIL GROUPS

The area has many different types of soil, each differing from others in fertility, crop adaptability, response to soil management, and productivity. Specific fertilizer requirements and soil management practices have not been worked out for individual soils, but general recommendations based on information gained by the State Agricultural Experiment Stations are usually followed. Some general information on management of broad groups of soils follows. For management of specific soils refer to the section on Soil Types and Phases.

MODERATELY WELL DRAINED AND WELL-DRAINED SOILS OF THE UPLANDS AND OLDER TERRACES

The moderately well drained and well-drained soils of the uplands and old terraces developed under a coniferous forest and are moder-

ately acid, strongly leached of plant nutrients, and characteristically low in supplies of organic matter and available nitrogen. The carbon-nitrogen ratio for newly cleared lands is relatively wide, and only small quantities of nitrogen are made available to crops from the soil. Investigations by Wheeting (*18*) indicate that cropping over a period of years tends to increase the organic matter content and narrow the carbon-nitrogen ratio, thus making more nitrogen available for crops.

On these soils the prime requisite for good crop production is addition of organic matter and nitrogen, which are best supplied and maintained by using legumes in crops rotations, plowing under green-manure crops, and adding all available barnyard manure. The cost of commercial nitrogen fertilizer is usually prohibitive unless it is applied to the more intensively grown crops. Phosphate fertilizer is generally beneficial and can be added with barnyard manure to good advantage. Responses to potash have been observed on certain of these soil types; they are, however, not so frequent as responses to nitrogen or phosphorus.

Although moderately acid, soils of this group appear to have an adequate supply of lime, for applications of lime have not yet appreciably increased yields. The soils are highly buffered, and prohibitive quantities of lime may be necessary to neutralize them.

No definite results have been determined for any of the minor elements. If sulfur is deficient it would be supplied adequately by the gypsum in applications of superphosphate. Studies by Baur, Huber, and Wheeting (*1*) indicate that alfalfa will respond if sulfur is applied to certain soils deficient in this element.

SOILS OF YOUNGER TERRACES AND ALLUVIAL FANS

The soils of the younger terraces and alluvial fans have been subjected to less weathering and leaching than soils of the uplands and old terraces and generally are less acid and higher in inherent fertility. Nevertheless, the nutrient deficiencies and crop responses to soil management are generally similar to those already discussed for soils of the uplands and old terraces.

SOILS OF ALLUVIAL FLOOD PLAINS

The soils of the alluvial flood plains are only slightly acid and high in inherent fertility, but under continuous cropping they are becoming deficient in both nitrogen and phosphorus. Favorable increases in yield have been obtained by using complete fertilizer. The most beneficial results are obtained by using phosphate and nitrogen fertilizers.

Few experiments have been conducted on the depressional or imperfectly drained soils of the alluvial flood plains. They appear to be lower in organic matter than soils of the depressions in the glaciated region. Applications of 6 to 8 tons an acre of manure, plowing under of green-manure crops, and use of rotations including legumes are important in maintaining their fertility. They appear to be particularly benefited by applications of phosphate fertilizer.

ORGANIC SOILS

The organic soils—peat and muck—are not heavily fertilized and are used principally for grain and forage crops.

943244—54——8

CROPS AND MANAGEMENT PRACTICES

GREEN-MANURE AND COVER CROPS

Green-manure crops offer an economical method of supplying nitrogen to the soil and have considerable effect in reducing leaching and thus holding plant nutrients for crops that follow. Legume green-manure crops add considerable nitrogen to the soil.

Vetch and clover are the most commonly used legumes. Rosen rye with hairy vetch or Rosen rye with common vetch are the most satisfactory green-manure or cover crops. They produce a heavy growth of green material. Wheat or oats are sometimes used in place of Rosen rye, but they are less desirable because they are more subject to winterkilling.

Green-manure or cover crops are more satisfactorily seeded in fall because their growth does not interfere with regular crops. The State Extension Service (*6*) recommends the following seeding mixtures; (1) 90 pounds of Rosen rye with either 30 pounds of hairy vetch or 50 pounds of common vetch and (2) 90 pounds of winter wheat with either 30 pounds of hairy vetch or 50 pounds of common vetch. For spring planting the State Extension Service recommends 60 pounds of field peas or 60 pounds of spring wheat with 60 pounds of field peas. Austrian peas are sown at the rate of 90 pounds an acre to 75 pounds or either Rosen rye or winter wheat, or if sown alone, 120 pounds of peas an acre.

Fall-planted crops should be seeded as soon as possible after the beginning of the fall rains. Spring seeding should be done late in February or in March on the well-drained soils, and a little later on the imperfectly drained soils.

The use of barnyard manure and superphosphate encourages more abundant growth of cover crops and conserves nutrients for the following crop. From 300 to 500 pounds an acre of superphosphate applied alone, with manure, or with 250 to 300 pounds of nitrate of soda, is beneficial. The superphosphate should be applied at the time the ground is prepared for seeding green-manure crops.

In rotations with small grains, satisfactory results are obtained if legumes are used every third year. Red and alsike clovers are the most common legumes. Alfalfa can be grown on the well-drained alluvial soils. Alsike clover is used where drainage is impaired. Superphosphate applied to legumes at the rate of 250 to 300 pounds an acre is beneficial and assures a sufficient quantity for the next crop.

PERMANENT AND TEMPORARY PASTURES

Permanent and temporary pastures aid in maintaining the fertility of the soil. The best pastures include three types of plants: Low sod-forming grasses, upright-growing grasses, and clovers to thicken the stand and add feeding value to the mixture. Pastures should be seeded early without a nurse crop. A pasture mixture recommended by the State Extension Service for well-drained soils of the uplands and terraces consists of 3 pounds each of English and Italian ryegrasses, 4 pounds of tall meadow oatgrass, 6 pounds of orchard grass, 2 pounds of Kentucky bluegrass, 1 pound of common white clover, 2 pounds of red clover, and 3 pounds of alsike clover (*7*). Recommended for the depressional or moist soils is a mixture consisting of 4 pounds each of Italian ryegrass, English ryegrass, and orchard grass,

3 pounds of Kentucky bluegrass, 2 pounds each of red and common white clovers, and 4 pounds of alsike clover. For the wetter areas, which are under water most of the winter, Reed canarygrass seeded at the rate of 10 pounds an acre is recommended.

Fall or winter dressings of 6 or 8 loads of manure an acre reinforced with 300 to 400 pounds of superphosphate improve the quality and yield of pasture. Under heavy grazing 40 pounds of nitrogen with 40 pounds of phosphorus usually produce the best results, although complete fertilizers may tend to increase the nutritive value.

HAY CROPS

The following hay crops and rates of seeding are recommended by the State experiment station: For mixed grass and legume hay, 8 pounds of alsike clover with 12 pounds of Italian ryegrass an acre; for grain-legume mixtures, 90 pounds of gray winter oats with 20 to 30 pounds of hairy or winter vetch or 90 pounds of spring oats with 50 pounds of field peas; and for alfalfa hay, 120 pounds of fall or spring oats and 16 pounds of alfalfa seed an acre. Red clover at 12 pounds to the acre may be substituted for alsike or mixed with it. Alsike clover is better suited to the wetter soils. Timothy may also be substituted for Italian ryegrass, and 40 pounds of common vetch may be substituted for the hairy vetch. If oats is used as a nurse crop, not more than 75 pounds an acre should be used. Recently orchard grass and alta fescue have become popular in pasture and meadow mixtures.

Grass, clover, or grass-legume mixtures are best sown in spring—late in February or in March. Grass can be seeded in fall, but clovers are subject to damage in winter. Fall-seeded grains or grain-legume mixtures should be seeded as early in fall as moisture conditions permit so the plants may have considerable growth before cold weather. Spring-seeded grains or grain-legume mixtures should be seeded as early as the soil can be properly prepared.

Alfalfa is difficult to establish except on the well-drained recent alluvial soils. The crops should not be seeded until late spring—about May 15 to June 15. The greatest difficulty in getting alfalfa started appears to be getting the nodule-forming bacteria established in the soil (*6*). Frequently the first seeding fails; the second may be successful.

Under irrigation alfalfa or grass-and-clover mixtures can be seeded any time up to September 1. Nurse crops are undesirable for hay seedings. They deplete the supply of available moisture and thereby slow the growth of the later crop. This is particularly true of nurse crops seeded with alfalfa.

The time for cutting hay is an important problem in western Washington. Weather is unsettled before July 1, and hay cut before that date may be severely damaged. On the other hand, hay cut after July 1 is overmature and of poor quality. The Experiment Station recommends early cutting. The loss of quality that may result because of unfavorable weather will usually not exceed the loss in quality certain to occur as a result of overmaturity.

Experiments have shown that 20 pounds of soluble nitrogen an acre added to manure is the most economical means of increasing yields of oat hay on Chehalis silty clay loam and Olympic silty clay loam,

rolling. This fertilization brought an increase from 2.73 to 4.02 tons an acre on Chehalis silty clay loam and an increase from 1.25 to 2.06 tons on Olympic silty clay loam, rolling (*5*). Probably these increases result because oats are heavy early feeders. They demand much nitrogen in spring, the time at which little is released by manure. Higher yields were obtained when 5 tons of manure and about 100 pounds of ammonium sulfate were applied than when 10 tons of manure was applied alone.

Experiments showed that legumes responded best to 6 to 8 tons of manure and 200 pounds of phosphorus applied together. Phosphorus conserves the nitrogen in the manure and should be added to it in the barn.

Experiments with commercial fertilizers show that 1–2–1, 1–2–2, or 1–1–1 mixtures are best for general crops (*19*). In other words, phosphorus should be equal to or in excess of nitrogen, and potassium should be less than or equal to phosphorus. Quantities of less than 20 pounds of nitrogen, 40 pounds of phosphorus, or 40 pounds of potash were not effective. Economical increases in yields of hay and grains are difficult to obtain.

PEAS

Peas are grown principally on the well-drained deep fairly heavy alluvial soils of the flood plains (*14*). Because of the danger of root rot, fusarium wilt, and other diseases, they should be grown on the same land not oftener than about once every 4 or 5 years. They may follow a sod crop in the rotation. Thorough preparation of the soil before seeding is important; the soil should be disked two or three times. Peas require large quantities of organic matter; therefore, 6 or 8 tons of manure should be added before planting unless alfalfa or some other legume was grown the preceding year. Application of 300 pounds of 18-percent superphosphate broadcast after the first disking or, better, drilled with the seed when planted is recommended. The Experiment Station[5] recommends a special drill in which the fertilizer can be placed about ½ inch to the side of the seed at the time of seeding.

The principal varieties of peas grown are the Alaska, Surprise, and Perfection for canning, and the Thomas Laxton, Gradus, and Alderman for frozen pack. New soils should be inoculated. Planting should start late in March or early in April and follow at 4- to 7-day intervals. Late peas are planted a few days to 2 weeks later than early varieties. The seed is sown at the rate of about 270 pounds to the acre (Perfection, about 300 pounds) at an average depth of about 3 inches. The vines make excellent silage or green feed. Vines should not be left in the field, for in this way diseases can be carried over.

STRAWBERRIES

Strawberries are grown principally on the gently sloping Salkum soils. The soil should be in good tilth, well drained, fertile, and contain abundant organic matter. Strawberries like sandier surface

---

[5] Baur, K., and Cummings, G. A. Effect of fertilizer placement on yield of peas used for frozen pack in western Washington. Western Wash. Expt. Sta. Cir. 108, 5 pp. 1942. [Processed.]

soils, but Salkum soils have good tilth and high moisture-holding capacity. Organic matter must be added, and fertilization is usually beneficial. A year before strawberries are planted, the soil should be worked to a good tilth and receive 15 to 20 tons of manure, or it should be planted to green-manure crops that are turned under before sowing to the regular crops. According to the State Extension Service a field in clover crops that was previously in strawberries or ferns should not be planted to strawberries again until 3 years have elapsed (*11*).

Usually the matted-row system is used; plants are set 24 to 36 inches apart in rows 4 feet apart. Settings can be made in spring or early fall. Marshall is the most common variety grown, but other varieties, as Ettersberg and Corvallis, are grown to small extent.

Fertilizers are best applied to strawberry beds after the harvest season when the plants accumulate food supplies for the next crop. The usual dressing is 6 to 8 tons of well-rotted manure supplemented with 400 to 600 pounds of superphosphate an acre. Without manure, 150 to 300 pounds of sulfate of ammonia, 250 to 500 pounds of superphosphate, and 60 to 120 pounds of muriate of potash an acre are used.

FILBERTS

Filbert growing is becoming more important in this area. The principal requirement (*12*) is a deep well-drained soil, for the root system extends to a depth of approximately 10 feet. Limited soil depth restricts root and top growth, and if the water table rises during any part of the season the lower roots are injured and their growth is inhibited.

Growing green-manure cover crops is the most successful and economical way of maintaining the fertility of soils used for filberts. Commercial fertilizers may be used satisfactorily to supplement the cover crop. Rosen rye and hairy vetch are best suited as cover crops and are sown at the rate of 90 and 30 pounds an acre, respectively.

The principal variety of filberts grown in Lewis County is the Barcelona, which has been pollenized with Du Chilly. About 11 percent of the trees—every third tree of every third row—are pollenizers.

MINOR FRUIT CROPS

Fruits of minor or local importance are sweet cherries, including the Royal Ann, Bing, and Lambert varieties; sour cherries, the most important of which is the Montmorency variety; Golden Delicious and Esopus Spitzenburg apples; and Bartlett and Anjou pears. Grapes include the Island Belle, Campbell Early, and Niagara varieties; blackberries, the Texas Early, Brainerd, and Evergreen. Cuthbert and Washington are the best-adapted raspberry varieties.

PRODUCTIVITY

Climate and soil are the main natural factors affecting productivity. Management and use of fertilizer are artificial, or man-controlled, factors. The best available summation of all factors contributing to productivity are crop yields over a long period of years. Whenever possible, such long-term yields were used in compiling table 4, which gives the yields of principal crops to be expected on soils of this county under common management not including supplemental irrigation.

TABLE 4.—*Average acre yields of principal crops to be expected on soils of Lewis Cou practices without supplemental irrigation* [1]

[Blank spaces indicate that soil is not adapted to particu

Soil	Corn silage	Oats	Wheat	Barley	Hay	
					Oats [2]	Mixec
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Baugh pumicy loam						2.5
Carbondale muck	10.0	90		40	3.0	3.0
Shallow (over dense clay)	8.0	55		20	2.0	2.5
Chehalis silt loam	10.0	80	45	30	3.0	3.4
Mottled subsoil	10.0	80	45	30	3.0	3.4
Chehalis silty clay loam	9.5	75	40	30	2.8	3.3
Mottled subsoil	9.5	75	40	30	2.8	3.3
Cinebar silt loam:						
Gently rolling	8.0	60	30	28	1.8	2.0
Hilly						
Undulating	8.0	60	30	28	1.8	2.0
Cispus pumicy sandy loam:						
Gently undulating						
Sloping						
Clackamas silty clay						2.0
Clackamas silty clay loam	6.5	50		20	1.6	2.0
Cove silty clay						2.7
Cove silty clay loam		60		20	2.5	2.8
Doty silty clay loam	8.0	55	30	28	2.2	2.3
Dryad silty loam	8.5	65	35	30	2.0	2.8
Dryad silty clay loam	8.0	65	35	30	2.0	3.0
Everson clay loam	8.5	40	20	25	2.0	2.0
Fitch gravelly sandy loam, undulating	5.0	20	10	15	1.5	1.6
Galvin loam, very gently sloping	7.0	60	25	25	2.8	3.0
Galvin silt loam, very gently sloping	7.0	60	25	25	2.9	3.0

Galvin silty clay loam:						
Gently sloping	6. 5	55	25	25	2. 8	3. 0
Very gently sloping	6. 5	55	25	25	2. 8	3. 0
Glenoma loam	8. 0	60	32	30	1. 8	2. 5
Glenoma silt loam	9. 0	70	36	35	2. 3	3. 2
Grande Ronde silt loam, shot phase	7. 0	55	25	25	1. 8	2. 0
Grande Ronde silty clay loam, shot phase	7. 0	55	25	25	2. 0	2. 0
Greenwater fine sand	-----	-----	-----	-----	-----	-----
Greenwater loamy sand	-----	-----	-----	-----	-----	-----
Greenwater sandy loam	-----	25	-----	-----	1. 5	1. 6
Klaber-Olequa silty clay loams	7. 5	65	25	28	2. 0	2. 0
Klaber silt loam, gravelly subsoil	7. 0	60	25	25	2. 2	3. 0
Klaber silty clay loam	7. 0	60	25	25	2. 2	3. 0
Gravelly subsoil	7. 0	60	25	25	2. 2	3. 0
Kopiah-Onalaska silty clay loams	7. 0	55	25	25	2. 2	2. 2
Kopiah-Salkum complex, sloping	6. 5	55	25	25	2. 0	2. 0
Kopiah silt loam	7. 5	60	25	25	2. 3	3. 0
Kosmos clay loam	-----	-----	-----		-----	3. 0
Lacamas silt loam	6. 0	45	-----	25	1. 7	2. 5
Lacamas silty clay loam	5. 5	40	-----	20	1. 6	2. 3
Lynden fine sandy loam	5. 0	50	20	30	2. 0	2. 0
Made land	-----	-----	-----	-----	-----	-----
Melbourne-Meskill silty clay loams	-----	40	-----	20	1. 8	1. 7
Melbourne silty clay, hilly	-----	-----	-----	-----	-----	-----
Melbourne silty clay loam:						
Hilly	-----	-----	-----	-----	-----	-----
Rolling	6. 0	40	20	20	1. 6	1. 6
Steep and hilly	-----	-----	-----	-----	-----	-----
Meskill-Melbourne silty clay loams	6. 5	45	22	25	1. 9	2. 0
Meskill silt loam, sloping	6. 5	50	25	20	2. 0	2. 0
Meskill silty clay loam:						
Moderately steep	-----	-----	-----	-----	-----	-----
Sloping	6. 0	45	20	20	1. 8	2. 0
Mossyrock silt loam	8. 5	65	40	30	2. 0	3. 0
Nesika clay loam, seep phase	-----	-----	-----	-----	-----	-----
Nesika gravelly loam:						
Gently sloping	-----	-----	-----	-----	-----	-----
Very gently sloping	4. 0	50	20	15	1. 5	2. 0

See footnotes at end of table.

TABLE 4.—*Average acre yields of principal crops to be expected on soils of Lewis Cou practices without supplemental irrigation* [1]—Cont

Soil	Corn silage	Oats	Wheat	Barley	Hay	
					Oats [2]	Mixe
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Nesika loam:						
Gently sloping	6.0	60	25	25	1.8	2.3
Very gently sloping	6.0	60	25	25	1.8	2.4
Nesika soils, undifferentiated	----	----	----	----	----	----
Newberg fine sandy loam	9.5	65	30	25	2.5	3.0
Newberg loamy fine sand	5.0	45	20	20	1.7	2.0
Newberg sandy loam	7.5	55	25	25	2.0	2.6
Newberg silt loam	10.0	75	30	30	2.8	3.2
Nisqually loamy sand	----	30	10	12	1.0	1.5
Olequa silt loam:						
Gently undulating	8.5	65	28	30	2.0	2.2
Sloping	8.5	65	28	30	2.0	2.2
Olympic silty clay loam:						
Hilly	----	----	----	----	----	----
Rolling	7.0	50	25	25	2.0	1.8
Olympic stony silty clay loam:						
Hilly	----	----	----	----	----	----
Rolling	----	----	----	----	----	----
Onalaska silt loam	7.0	50	25	25	2.0	2.2
Onalaska silty clay loam	7.0	50	25	25	2.0	2.0
Pilchuck and Puyallup loamy sands	4.5	40	15	20	1.5	1.5
Pilchuck gravelly sand	----	----	----	----	----	1.1
Pilchuck loamy sand	----	----	----	----	----	----
Over Puyallup fine sandy loam	----	----	----	----	1.3	1.2
Pilchuck sand	----	----	----	----	----	----
Puget silt loam	10.0	80	40	35	3.0	2.5
Puyallup fine sandy loam	11.0	75	40	35	2.8	2.8
Puyallup loamy fine sand	7.0	45	25	25	2.0	2.0

Puyallup silt loam	12.0	80	40	35	3.0	2.8
Reed clay						2.7
Reed silty clay loam		60		20	2.5	2.8
Riffe loam	6.0	50	25	25	1.7	2.0
Riffe sandy loam	6.0	50	22	20	1.7	1.9
Rifle peat		70	25	30	3.0	3.0
Pumicy		65	20	25	2.2	2.4
Shallow (over dense clay)		60	20	25	2.0	2.3
Riverwash						
Rough broken land						
Olympic soil material						
Rough mountainous land:						
Olympic and Cispus soil materials						
Olympic soil material						
Olympic, Wilkeson, and Cispus soil materials						
Wilkeson soil material						
Salkum silty clay loam:						
Deep, nearly level	7.0	55	30	25	1.8	2.0
Moderately steep						
Rolling	6.5	50	30	20	1.5	1.6
Rolling, deep	7.0	55	30	25	1.8	2.0
Undulating	6.5	50	30	20	1.5	1.6
Scamman-Lacamas complex	6.0	45		20	1.8	2.3
Scamman silt loam	8.5	60	25	25	2.2	2.9
Scamman silty clay loam	8.0	55	25	25	2.0	3.0
Schooley loam	8.0	70	25	30	2.5	3.0
Schooley silt loam	9.0	75	30	30	3.0	3.4
Siler fine sandy loam	8.5	75	25	25	2.5	3.0
Siler silt loam	9.0	80	30	30	3.2	3.5
Snohomish silt loam, pumicy	9.0	60	25	30	3.0	3.0
Snohomish silty clay loam	10.0	85	30	35	3.5	3.3
Spanaway gravelly sandy loam		35	15	15	1.0	1.5
Sultan silt loam	11.0	90	40	35	3.8	4.0
Tower silty clay loam	7.0	45		25	1.7	2.5
Vader loam, hilly						
Wapato-Chehalis silty clay loams	9.0	80	35	35	3.0	3.0
Wapato-Galvin complex	9.0	80	35	35	3.0	3.3
Wapato silt loam	9.0	80	35	30	3.2	3.3

See footnotes at end of table.

TABLE 4.—*Average acre yields of principal crops to be expected on soils of Lewis Cou practices without supplemental irrigation* [1]—Cont

Soil	Corn silage	Oats	Wheat	Barley	Hay	
					Oats [2]	Mixe
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Wapato silty clay loam	8. 5	80	30	30	3. 0	3. 0
Wilkeson silt loam:						
Hilly	---	---	---	---	---	---
Rolling	---	---	---	---	---	---
Winlock silt loam, gently undulating	6. 5	45	25	25	1. 8	2. 2
Winlock silty clay loam:						
Gently undulating	5. 0	35	20	15	1. 4	1. 4
Level	5. 0	35	20	20	1. 5	1. 5
Sloping	5. 0	35	20	15	1. 4	1. 4
Winston gravelly loam, gently undulating	5. 0	45	20	20	1. 4	1. 6
Winston gravelly sandy loam:						
Gently undulating	4. 5	40	15	20	1. 2	1. 3
Moderately steep	---	---	---	---	---	---
Sloping	4. 5	40	15	20	1. 2	1. 3
Winston loam, gently undulating	5. 5	50	20	25	1. 6	1. 8
Winston silt loam, nearly level	6. 5	55	25	25	1. 8	2. 0

[1] Yields under good management, which includes skilled operation, use of adapted varietie supplemental irrigation, may be as much as 100 percent greater than those indicated. The g management will tend to be on the soils giving low yields under common or ordinary manage

[2] Usually an oat-annual legume mixture.

[3] Air-dry weight equivalent to that of hay.

Yields for the poorly drained soils are based on drained and protected conditions. In other words, all yields listed in table 4 are for adequately drained soils and well-cleared fields. Undrained and overflow lands have little value other than for timber and pasture. Reclaimed areas are not shown on the map.

Table 4 shows the relative productivity of soils in the county, but other parts of the text, particularly the section on Soil Types and Phases, must be referred to for information concerning the factors contributing to productivity. A low yield for a particular crop may be caused by unfavorable relief, drainage, or climate rather than lack of fertility. The physical characteristics of soils, especially in relation to moisture storage, are very important in this part of the State. Erodibility, however, is not especially important in this county.

ADDITIONAL FACTS ABOUT LEWIS COUNTY

ORGANIZATION AND SETTLEMENT

Lewis County was created in 1845 as part of the Oregon Territory; it was the first county organized in the State of Washington. Exploring parties first came to the area from Fort Vancouver in the 1820's. Soon afterward French Canadians settled on the Cowlitz Prairie near Toledo, and in 1833 Simon Plamondon founded the Cowlitz Farm on this prairie. The Hudson's Bay Company later brought immigrants to the farm, which in 1843 was established as the Puget Sound Agriculture Company, a part of the Hudson's Bay Company.

In 1845 John R. Jackson located 9 miles southeast of Chehalis on the prairie that bears his name. The first court in Lewis County was held here in 1851. In 1847 the first census of Lewis County, which then included a much larger area than now, reported a population of 268.[6] The St. Francis Xavier Mission, built on the Cowlitz Prairie in 1838, was the first church established in the State. The mission was later reorganized as a mission school, which still exists.

The Donation Claims law, enacted by Congress in 1850, was the first sure basis by which settlers could obtain title to land. Some 96 Donation Claims of many odd shapes still exist in Lewis County.

Chehalis, originally known as Saundersville, was settled in the early 1850's. Centralia was organized in 1875, although a post office at that point has served the neighborhood since 1857. Napavine was first established as a lumber camp in 1852. Silver Creek and Alpha were first settled in 1868, and the first white man entered the Big Bottom in 1854, although settlement in this area did not begin until some 25 years later.

PUBLIC FACILITIES

Early transportation was principally by boats that made regular trips up the Cowlitz River as far as Toledo and occasional runs to a landing south of Salkum.

The first railroad was built to Centralia by the Northern Pacific in 1872. Now the county is served by the main lines of the Union Pacific Railroad, Northern Pacific Railway, and Great Northern Railway, which operate jointly over the same route. A branch line

[6] COFFMAN, N. B. OLD LEWIS COUNTY. An address delivered before the Southwest Washington Pioneers, Rochester, Wash., 1936.

of the Northern Pacific Railway runs between Chehalis and the harbor at Willapa Bay in Pacific County, and a branch line of the Chicago, Milwaukee, St. Paul, and Pacific Railroad operates between Tacoma and Morton. The Cowlitz, Chehalis, and Cascade Railway carries freight only. Many logging railroads have been built into more isolated parts of the county.

United States Highway No. 99 runs north and south through the western part of the county. Surfaced State highways branch from this highway to the coast and to Mount Rainier National Park. A recently completed highway now offers a direct route to Yakima through Randle, Packwood, and Mount Rainier National Park. Well-improved State and county roads serve all outlying communities. The mountainous country, however, is accessible only by a few forest-protection roads, trails, and logging railroads.

The Rural Electrification Administration has recently made electric power available to nearly all the farms and communities. This power is obtained from the main transmission line from Bonneville Dam. Telephone service is also available in most rural sections. High schools and grade schools are located in the principal towns and districts, and school-bus service is available in outlying areas. The church denominations are well represented in the towns, and churches or assembly halls are located in readily accessible local community centers.

INDUSTRIES

Lumbering, with its allied industries, is one of the principal sources of revenue in the county. The annual average of 450,000,000 board feet of logs cut from between 1925 and 1938 has lately been increased considerably (*10*). In 1930, 8,000 people were directly or indirectly dependent upon the lumber industry, with 4,000 directly dependent. In 1941, about 50 mills were located throughout the county. The largest, at Onalaska, cut more than 500,000 board feet of lumber a day. According to timber surveys, there were an estimated 37,274,108,000 board feet of timber in the county in March 1933. Of this total 24,-020,745,000 were Douglas-fir; 7,133,713,000, hemlock; 2,242,372,000, cedar; 3,492,902,000, silver fir; and 384,376,000 other types.

Douglas-fir supplies the largest number of lumber products; cedar is important in the manufacture of shingles. Hemlock is used largely for pulpwood.

Large deposits of sub-bituminous and lignite coal occur in the county, and anthracite coal has been reported near Morton (*4*). Coal mining was much more important during the first part of the century than now, although some of the mines once abandoned are now back in operation. Coal production in 1937 totaled 38,000 tons net, valued at $121,600. If prices increase, coal mining could again become a leading industry in the county.

The cinnabar deposits occur in the Morton and Randle districts. During the last few years the production of mercury from the Morton mines was valued at more than $750,000.

AGRICULTURE

Settlement of Lewis County first began on the open and fertile Cowlitz Prairie. Immigrants arriving through Oregon from the East and Midwest between 1830 and 1850 took up most of the prairies by Donation Claims, and then began to clear the rich flood plains of

the Chehalis River. Following denudation of the uplands by the rapidly expanding logging industry late comers settled in these less fertile regions. Toward the close of the century lumbering became the major industry, and soon a greater part of the lower lying potential agricultural lands were logged off. Consequently, logging operations are now confined largely to the more remote sections and mountainous parts of the county.

The Cowlitz Farm, founded in 1833, produced the first crops grown in the county. This farm produced annually 8,000 to 10,000 bushels of wheat, about 4,000 bushels of oats, and lesser quantities of potatoes, barley, flax, and small crops (*15*). Stock on the farm included horses and about 500 head of sheep. Most of the produce was used to supply the Hudson's Bay Company posts at Vancouver, Fort Victoria, and Fort Nisqually. Surpluses were sold to the Russians in Alaska. The laborers were English Canadians, French Canadians, Hawaiians, and Indians.

CROPS

The acreage of the principal crops and the number of bearing fruit trees and grapevines in the county in recent years is given in table 5.

TABLE 5.—*Acreage of the principal crops and the number of bearing fruit trees and grapevines in Lewis County, Wash., in stated years*

Crop	1919	1929	1939	1949
	Acres	*Acres*	*Acres*	*Acres*
All hay	30, 416	33, 162	41, 898	34, 779
Timothy and clover, alone or mixed	10, 388	8, 255	11, 879	14, 823
Small grains cut for hay	13, 441	12, 859	16, 376	7, 048
Legumes	534	1, 183	1, 029	(1)
Alfalfa	81	662	2, 207	1, 321
Clover alone	2, 004	3, 621	158	(1)
Other tame hay	3, 332	4, 453	8, 302	6, 646
Wild hay	636	2, 129	1, 947	4, 941
Oats:				
Threshed	13, 544	12, 055	14, 035	13, 450
Unthreshed	(1)	878	1, 049	964
Wheat, threshed	5, 468	5, 270	4, 018	4, 363
Barley, threshed	861	1, 081	946	1, 368
Corn:				
For silage	[2] 1, 060	236	477	107
For forage	249	278	332	36
For grain	77	20	26	1
Potatoes	2, 033	556	566	(3) 36
Other vegetables	139	203	305	1, 265
Strawberries	141	701	596	455
Other berries	164	66	54	142
	Number	*Number*	*Number*	*Number*
All nuts ... Trees	161	[4] 1, 449	[4] 13, 306	19, 261
Apples ... do	79, 815	50, 796	33, 730	23, 465
Cherries ... do	9, 030	29, 886	13, 288	9, 256
Plums and prunes ... do	21, 969	15, 069	12, 560	7, 701
Pears ... do	10, 915	9, 326	7, 712	4, 721
Peaches ... do	1, 080	669	386	4, 425
Grapevines	403	892	2, 141	2, 510

[1] Not reported.
[2] All silage crops.
[3] Does not include acres for farms with less than 10 bags harvested.
[4] Mostly hazelnuts.

The largest acreage is in hay, which has increased consistently with agricultural expansion. In 1949, most of the hay crop consisted of timothy and clover, and the next largest part was small grains cut for hay. Alfalfa and legumes have become important during the last two decades, but are still grown on only a small percentage of the land.

Oats are by far the most important cereal crop; wheat is the only other cereal of any significance. The acreage in potatoes has decreased rapidly since 1919 and was only 36 acres in 1949. The decrease is due largely to potato diseases and insects such as the potato flea beetle. The acreage in vegetables has been of but minor importance. Strawberries, the only important berry crop, have been planted in significant acreages only since 1930.

The most important fruit crop has been apples, followed in order of importance by cherries, plums and prunes, pears, and peaches. The total number of apple trees, has been decreasing rather steadily. The number of plum, prune, and pear trees has also declined. The number of cherry trees increased up to 1929 and declined thereafter. Filbert planting has expanded considerably during the last few years and indicates possible future importance.

LIVESTOCK

The number of livestock on farms of the county is given in table 6 for stated years.

TABLE 6.—*Number of livestock on farms in Lewis County, Wash., in stated years*

Livestock	1920	1930	1940	1950
Cattle	25, 156	29, 579	[1] 29, 765	31, 426
Swine	10, 319	5, 895	[2] 5, 201	3, 991
Goats	269	601	[2] 334	([3])
Sheep	3, 574	8, 763	[4] 2, 332	2, 503
Horses	5, 524	4, 490	[1] 4, 285	2, 046
Chickens	180, 679	390, 678	[2] 289, 692	[2] 260, 129
Beehives	4, 179	2, 577	932	1, 324

[1] Over 3 months old, Apr. 1.
[2] Over 4 months old, Apr. 1.
[3] Not reported.
[4] Over 6 months old, Apr. 1.

Cattle, chiefly dairy breeds, have been by far the most important livestock. The numbers of sheep and goats have fluctuated, no trend being apparent. Less than half as many swine were raised in 1950 as in 1920. The increased use of tractors is undoubtedly responsible for the decrease in the number of horses since 1920. Poultry raising increased greatly until 1930 and is still a major industry.

NUMBER, SIZE, AND TENURE OF FARMS

The total number of farms in the county increased from 3,030 in 1920 to 3,396 in 1950. The number of acres in farms, however, increased from 237,429 in 1930 to 304,253 in 1950. There were 67,294 acres in cropland in 1929 and 105,231 acres in 1949.

In 1950, 393 farms were less than 10 acres in size; 697 farms, between 10 and 30 acres; 660, between 20 and 50 acres; 238, between 50 and 70

acres; 462, between 70 and 100 acres; 294, between 100 and 140 acres; 217, between 140 and 180 acres; and 435, over 180 acres. Consequently approximately 32.1 percent of the farms consisted of less than 30 acres, 26.4 percent between 30 and 70 acres, and 41.5 percent over 70 acres. Many of the farms of 10 acres or less are subsistence farms, the family deriving a large share of its income from other sources. A large percentage of the chicken farms occur in this group.

In 1950, 94.4 percent of the farms were operated by owners, 5.4 percent by tenants, and 0.2 percent by managers. This tenure has remained remarkably uniform during the last 40 years.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of environment acting upon soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) physical and mineralogical composition of the parent material; (2) climate under which the soil material has accumulated and existed since accumulation; (3) relief, or lay of the land, which determines the local or internal characteristics of soil, as its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting upon the soil material—the plants and animals living upon and in it: and (5) the length of time climatic and biologic forces have acted upon the soil material.

Lewis County lies south of the Puget Sound Basin. It is bordered on the west by the Willapa Hills, 1,000 to 2,500 feet high, and on the east by the Cascade Range, which has an average elevation of 6,000 feet. The principal farming areas are in the west-central part of the county at elevations between 200 and 1,000 feet. The two mountain ranges, particularly the Cascades, act as barriers to the prevailing westerly winds and largely determine the distribution of rainfall throughout the county. From a low of 40 to 45 inches in the western part of the county, rainfall progressively increases eastward to 90 inches or more in the higher mountains. Little effective rain falls from late in June to mid-September. The soil in the lower areas is seldom frozen in winter and then only for short periods.

Over most of the county the native vegetation consists of a dense growth of conifers and a ground cover of mosses, ferns, and shrubs. Deciduous trees and brush are common in the stream valleys and depressions. A few areas in the county are grass-and-fern covered prairies relatively free of timber except for a few oaks and limby or stunted fir trees.

The Northern Cascades are remnants of a former peneplain uplifted near the end of the Pliocene epoch. The Southern Cascades are the result of the building up of successive lava flows, principally of andesite. The western slopes of the Cascades—maturely dissected and strongly modified by glacial erosion—are composed dominantly of Miocene volcanic material. Many formations are included but the materials are dominantly basic in composition. Nonetheless, inclusions of granodiorites, rhyolites, and other acid igneous rocks do occur.

The Coast Range, or Willapa Hills, is composed of sedimentary and basaltic rocks of Tertiary age. The sedimentary rock formations are of sandstone, shaly sandstone, shale, and conglomerate; the igneous

formations are lava flows of varying texture, volcanic tuffs, dikes, sills, and intrusive Plutonic rocks (*16*). The upwarp of the Black Hills, composed primarily of andesitic lavas, extends into this county in the region northwest of Morton, which is a part of the national forest.

The downfold, or structural, valley connecting the Puget Sound Basin with the lower Cowlitz Valley lies between these two mountain ranges. The materials covering the major part are principally those forming the ancient terrace group of soils, largely soils of the Salkum series.

The parent material of the Salkum soils resembles conglomerate but more probably is of glacial or outwash origin. This material was likely deposited in a glacial period prior to the Admiralty period referred to by Bretz (*2*). The Salkum plain has a uniform slope for about 15 miles, dropping from an elevation of nearly 1,000 feet near Burnt Ridge School north of Salkum to less than 400 feet near Winlock. From Burnt Ridge School the plain fans out to the northwest beyond Chehalis, and to the southwest extends to near Vader. The west side of the plain ends abruptly against the low hills of the Coast Range. Indications are that the flow of outwash was from the east.

The valley of the Cowlitz River has only two places where glaciers from the Puget Sound could have entered—one is the low divide at Napavine, the other is the drift valley between Mineral and Morton. No evidence exists that any Puget Sound glacial materials came farther toward the Napavine divide than Centralia. The drift valley between Morton and Mineral was probably closed by ice from Mount Rainier before any glacier from the Puget Sound area reached this point; therefore, no outwash from Puget Sound glaciation ever reached the valley of the Cowlitz River.

Probably then, the Salkum material originated from the outwash left by early glaciers coming from Mount Rainier. Later glaciers from the same direction destroyed evidences of the Salkum material east of its present location. These later glaciers were less extensive than the earlier and up to an elevation of about 2,500 feet deposited a thin mantle of drift and fine material over the major part of this eastern area. The later glaciers may also have had a part in the formation of the Wilkeson and the Cinebar soils.

Fine-textured, relatively gravel-free deposits over a thin glacial mantle give the impression that Wilkeson and Cinebar soil material was deposited under water when much of this area was lower than it is now or that these soils developed from wind-blown pumice. Particles of fine and highly weathered pumice fragments are scattered through the profile.

The older soils in this county—those of the uplands and old terraces—have developed from severely weathered parent material that has been in place much longer than glacial materials of the Puget Sound Basin. This weathering has tended to modify differences among soils that would result from parent materials, and as a result, soil characteristics are more uniform. The more youthful soils of the terraces, fans, and outwash plains have developed the characteristics of the older soils, but to less extent.

Most characteristic of the well-drained soils of the uplands and old terraces that have a coniferous cover are shotlike particles and a

pronounced, stable and durable, brown, granular or angular fragmental structure in the surface soil and subsoil. The structure aggregates are very similar to those of the lateritic soils.

The silty clay loam soils of the Olympic, Melbourne, and Salkum series occurring in the western part of the county have structural particles coarser and more angular than those particles in the lighter silt loam soils of the Wilkeson, Cinebar, and Glenoma series in the eastern part.

All the well-drained soils of this county are friable, can be tilled under a wide range of moisture conditions, and absorb water readily. Erosion loss is very slight. The organic matter is low in bases, decomposes slowly, and mixes little with the soil. The soils have a brown or slightly dark-brown surface color in their virgin conditions, and a slight reddish cast in cultivated fields, especially when wet. Many of the zonal soils have a silty clay loam texture, but most of them have a silt loam or heavier texture.

The well-drained soils of the Pacific Northwest developed under coniferous cover have been classified with the Gray-Brown Podzolic soils (*13*). Several differentiating characteristics occur, however. In recognition of these Nikiforoff (*9*) considered soils of this part of the United States to be a new group, which he designated as Pink-Brown soils. Although soils in western Washington show evidences of podzolic processes, they have characteristics of lateritic soils.

Analyses of the colloidal fraction of the different horizons of Salkum silty clay loam, undulating, a good representative of the well-drained soils in the western part of Lewis County, are given in table 7. In table 8 are given mechanical analyses and organic-matter content of this same soil.

TABLE 7.—*Analyses of the colloidal fraction of Salkum silty clay loam, undulating*

Depth	SiO_2	Fe_2O_3	Al_2O_3	$\frac{SiO_2}{R_2O_3}$	$\frac{Fe_2O_3}{Al_2O_3}$	Loss on ignition
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–10	45. 48	10. 00	28. 15	2. 24	0. 224	(1)
10–22	46. 08	10. 16	29. 44	2. 18	. 218	11. 89
22–30	46. 18	10. 83	31. 27	2. 06	. 218	10. 84
30–38	46. 00	11. 66	32. 24	1. 97	. 231	10. 93
38–48	44. 86	11. 07	34. 17	1. 85	. 205	(1)
48–72	44. 02	10. 63	34. 17	1. 82	. 198	12. 37

[1] ot determined.

In comparing the composition of the colloidal fraction of Salkum silty clay loam, undulating, with those of the great soil groups analyzed by Byers, Alexander, and Holmes (*3*) it is found that the silica content is fairly uniform throughout the profile and is only slightly higher in the B horizon. In this respect the Salkum soil is similar to the Miami soils mapped elsewhere in the United States. The Fe_2O_3

TABLE 8.—*Mechanical analyses and organic-matter content of Salkum silty clay loam, undulating* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–10	0.4	1.4	1.4	3.1	4.4	60.1	29.2	41.5	6.0
10–22	.4	1.2	1.3	2.8	4.2	57.0	33.1	44.5	2.5
22–30	.3	1.4	1.2	2.7	3.7	52.9	37.8	48.6	.5
30–38	.5	1.3	1.2	2.8	4.2	52.0	38.0	49.1	.5
38–48	3.3	4.5	2.2	3.9	4.2	37.8	44.1	52.0	.3
48+	3.0	3.3	2.1	4.3	5.1	34.1	48.1	56.5	.4

[1] Analysis by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering; sample taken in section 31, township 14 north, range 1 west.
[2] Organic matter and mineral matter dissolved by H_2O.

content increases only slightly in the B horizon and is thus more like that of the soils of the Cecil series. The silica-sesquioxide ratio is fairly narrow. Although narrower than in the Gray-Brown Podzolic soils it is wider than in the Red Podzolic soils. The absence of a horizon of iron accumulation and the gradual lowering of the Fe_2O_3 and Al_2O_3 ratio with depth indicate that the sesquioxides are being leached from the surface, though no definite zone of accumulation is apparent. Comparing the Fe_2O_3, it is again apparent that there is no tendency toward an ortstein development, although there is a slight increase in iron content in the lower B horizon.

Like the laterites, the soils have water-stable aggregates that are friable, granular, and permeable even though heavy-textured. The soil-forming process, on the other hand, appears to be both podzolic and lateritic in tendency. Possibly during the earlier stages of development of the older soils, there was a more lateritic type of climatic influence.

Differences in climate must be considered when comparing soils of western Washington with those in the eastern part of the United States. Dry weather in summer evidently has considerable effect upon the weathering process. The podzolic processes are dominant, and under acid conditions the iron and alumina are readily made soluble (*17*). The dry summers, however, inhibit the general downward movement of water, and thus no textural B horizon is formed. Instead the iron and alumina precipitate around localized nuclei, forming shot-like particles, and because of the low solubility of sesquioxides and phosphate subsequent to dehydration, this cementing of material is irreversible. The shotlike particles are much higher in sesquioxides than the surrounding soil, and Wheeting considers that they constitute a diffused B horizon or ortstein scattered through the surface soil and upper subsoil. The shot cannot be attributed to imperfect drainage, for it also occurs in the excessively drained soils; however, it does not occur under prairie vegetation.

The pH values of several of the soils by horizon is given in table 9.

TABLE 9.—*pH determinations for several soils of Lewis County, Wash.*[1]

Soil	Depth	pH
	Inches	
Salkum silty clay loam, undulating	0–10	5. 7
	10–22	5. 6
	22–30	5. 3
	30–38	5. 3
	38–48	5. 2
	48–72	5. 3
Melbourne silty clay loam, hilly	0–1	5. 7
	1–12	6. 0
	12–22	5. 4
	22–38	5. 3
	38–46	5. 3
	46–72	5. 0
Olympic silty clay loam, rolling	0–6	5. 8
	6–22	5. 7
	22–45	5. 7
	45–72	5. 5
Cinebar silt loam, gently rolling	0–2	4. 8
	2–10	5. 5
	10–16	5. 8
	16–35	5. 9
	35–72	5. 8
	72–96	5. 7
	96+	5. 4
Mossyrock silt loam	0–3	6. 0
	3–14	6. 2
	14–21	6. 4
	21–40	6. 3
	40–72	6. 2
Chehalis silty clay loam	0–15	6. 3
	15–32	6. 3
	32–40	6. 3
	40–72	6. 4

[1] Analyses made by glass-electrode method in 1:5 soil-H_2O suspension.

The pH of 4.8 given in table 9 for the organic litter of Cinebar silt loam, gently rolling, was from the only virgin sample taken; the samples of Melbourne silty clay loam, hilly, were taken from logged land where the litter was high in content of leaves from deciduous brush and trees. No sharp changes occur in any of the horizons. The older soils are in general more strongly acid and have more of the shotlike particles than the younger soils.

The relative fertility of soils of different ages is shown in plate 6, *A*. Alfalfa grown in the greenhouse on virgin samples of Salkum silty clay loam, Cinebar silt loam, and Chehalis silty clay loam shows that the recent Cinebar soil has higher fertility than the Salkum soil and that the Chehalis soil, youngest of the three, has still higher fertility.

CLASSIFICATION OF SOILS

A number of the important great soil groups are represented by one or more series in the county. In the zonal order are soils series of the "brown lateritic,"[7] Brown Podzolic, Podzol, and Prairie great soil

[7] Accepted names of great soil groups are capitalized; names of tentative soil groups are placed in quotation marks and not capitalized.

groups; in the intrazonal, soils of the Humic Gley, Planosol, Bog, and Half Bog great soil groups; and in the azonal, Alluvial soils (well to moderately well drained) and Alluvial soils (poorly drained).

Many of the soils have not been studied enough to determine definitely that they belong distinctly to one great soil group and not another. In time some of the soils now listed under one great soil group may be changed to another, or a new group name may be given to them.

ZONAL SOILS

"BROWN LATERITIC" SOILS

Zonal soils are any one of the great groups of soils having well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation.

Some of the soils in the western part of Lewis County are "brown lateritic". They developed on the well-drained uplands, terraces, fans, and outwash plains under forest cover and show the following general characteristics: (1) Thin dark-brown organic layer; (2) brown to faintly reddish-brown moderately acid, friable, granular, and fairly thick surface soil, predominantly heavier textured and slightly darker in the upper part, that grades to a yellowish-brown permeable and granular subsoil without appreciable compaction or enrichment in clay or sesquioxides; (3) in the surface soil and upper subsoil numerous spheroidal shotlike pellets grading from very small to the size of peas or marbles; (4) highly weathered parent materials from shale and sandstone, basalt rock, matrix of softened gravel and clay, or material of mixed origin from various rock sources; and (5) acid (about pH 5.5) throughout the profile and possibly becoming slightly more acid with depth.

These characteristics are most strongly developed in the older soils of the uplands in the western part of the county and less strongly developed in the more recent terrace and outwash plain soils.

The following soil series are tentatively classified as "brown lateritic": Grande Ronde, Melbourne, Nesika, Olequa, Olympic, Onalaska, Riffe, Salkum, Vader, and Winston.

Salkum silty clay loam, undulating, typical of the "brown lateritic" group, has the following characteristics:

A_o. 1½ to 0 inches, moderately to strongly acid dark-brown organic mat of leaves, twigs, cones, and moss.

A_{1cn}. 0 to 12 inches, brown[8] (10YR 5/3) or pale-brown (10YR 6/3) silty clay loam; dark brown (7.5YR 3/2) when wet; many shotlike concretions; friable and fairly granular; aggregates do not readily slake in water and are medium acid; a few rounded fragments of quartzite scattered in places throughout the soil and substratum.

B_{1cn}. 12 to 30 inches, a light yellowish-brown (10YR 6/4) silty clay loam having a slight reddish (7.5YR 3/4) tinge when wet; strongly acid; numerous shot; very granular or angular fragmental structure; slightly plastic in the upper part and more plastic with less shot in lower part.

---

[8] Provisional soil color names proposed by the 1946 committee; color of dry soil unless otherwise stated. Symbols following color name express Munsell notations.

B_3. 30 to 38 inches, very pale-brown (10YR 7/4) silty clay loam; yellowish brown (7.5YR 5/4) when wet; relatively harsh angular interlocking structure; surfaces of the structural units highly coated with colloids; slightly plastic but permeable; strongly acid.

B_4. 38 to 48 inches, yellow (10YR 8/6) or yellowish-brown strongly weathered, strongly acid, matrix of clay and softened variegated gravel of the upper part of the parent material; units highly coated with colloids; soil very plastic and penetrated by roots and water only with difficulty.

C. 48 inches+, parent material of plastic clay and gravel; gravel concentric, highly weathered, easily cut through with a knife or spade, and from a wide variety of rounded but unassorted rocks; sharp contrasts of bright coloration, with reds, yellows, and purples on fresh road cuts; strongly acid.

In general the profile characteristics of the other soils classified with the "brown lateritic" group are similar to those of Salkum silty clay loam, undulating.

The mechanical analyses and organic-matter content of Salkum silty clay loam, undulating, are shown in table 8. Table 10 gives similar data for Grande Ronde silty clay loam, shot phase, and Onalaska silty clay loam.

TABLE 10.—*Mechanical analyses and organic-matter content of Grande Ronde silty clay loam, shot phase, and Onalaska silty clay loam* [1]

Soil name and depth of sampling in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Grande Ronde silty clay loam, shot phase:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–12	6.7	7.5	3.5	9.2	10.3	45.7	17.1	28.2	4.4
12–24	.2	1.1	1.6	9.3	13.0	47.9	26.9	37.7	.1
24–40	.2	.9	1.7	10.8	13.7	35.5	37.2	46.7	0
40+	.3	2.4	3.6	15.4	16.3	33.2	28.8	38.7	.1
Onalaska silty clay loam:									
1–6	1.5	2.2	1.7	6.4	10.8	59.8	17.6	31.0	9.7
6–20	.4	1.5	1.9	6.7	9.8	58.0	21.7	34.1	.8
20–42	.9	1.8	1.7	5.7	7.5	49.6	32.8	44.1	.9
42–72	9.4	17.9	9.0	17.5	9.8	13.6	22.8	25.9	.4
72+	14.7	16.5	8.3	12.1	8.7	18.6	21.1	26.4	.3

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering; sample taken of Grande Ronde soil in section 20, township 11 north, range 3 west; sample taken of Onalaska soil in section 11, township 11 north, range 1 west.

[2] Organic matter and mineral matter dissolved by H_2O_2.

BROWN PODZOLIC SOILS

The soils of western Washington tentatively classified as Brown Podzolic show more visible evidence of having developed under a podzolization process than soils of the "brown lateritic" group. They are very weakly podzolized, as judged by evidence of an A_2 horizon, and do not have the same degree of granulation as the "brown lateritic" soils.

The soils classified in the Brown Podzolic group in this county belong to the Cinebar, Glenoma, and Wilkeson soil series.

Soils of the three series occur in the eastern part of the county under cool climate and high precipitation. They are characterized by brown silt loam softly granular surface soil over deep mellow yellowish-brown silt loam subsoil that rests at depths of 5 to 8 feet on a thin till-like substratum. In places the material above the substratum is disintegrated fine pumice. The Wilkeson soils occur at higher elevations east of the Cinebar soils and have a more acid surface soil and heavier textured more plastic subsoil.

A description of a profile of Cinebar silt loam, gently rolling, taken about 3 miles northeast of Silver Creek, is as follows:

A_0. 2 to 0 inches, strongly acid dark-brown mat of moss, twigs, cones, and needles; lower ½ inch well decomposed, nearly black, and greasy.

B_{11cn}. 0 to 10 inches, medium or strongly acid brown (10YR 4/3) silt loam becoming dark brown (7.5YR 3/2) when wet; shows slight variegation with brown and yellowish-brown particles, contains many small shot, and has a very friable rounded granular or soft crumb structure; more than 10 percent of layer is organic matter.

B_{12cn}. 10 to 16 inches, yellowish-brown (10YR 5/4) gradiation zone.

B_{2cn}. 16 to 35 inches, light yellowish-brown (10YR 6/4) strongly acid mellow loam; a few scattered shot; forms soft spherical crumbs.

C_1. 35 to 72 inches, strongly acid light yellowish-brown (10YR 6/4) loam, slightly darker than layer above; firm massive structure easily breaks into mellow loose material.

D_1. 72 to 96 inches, very pale-brown (10YR 7/3) loam and strongly weathered gravel stained with rust brown; gravel partly cemented.

D_2. 96 inches+, strongly acid light-gray partly cemented gravel, coarse sandy loam, and fine material resembling till; rests upon country rock at highly variable depths.

Table 11 gives mechanical analyses and organic-matter content of a representative sample of Cinebar silt loam, gently rolling. The Glenoma soils differ slightly from the Cinebar in being influenced by recent pumice and have a darker colored profile. The darker color of Glenoma soils may possibly result because they have more grassy vegetation than the Cinebar soils.

TABLE 11.—*Mechanical analyses and organic-matter content of Cinebar silt loam, gently rolling* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
2–0	0.5	2.2	4.3	13.9	15.9	48.6	14.6	25.4	48.4
0–10	2.3	3.0	2.9	8.2	11.3	62.2	10.1	25.6	10.9
10–16	1.6	5.5	5.1	11.5	14.8	52.9	8.6	18.6	3.7
16–35	.7	3.8	7.6	19.2	17.5	42.7	8.5	16.4	.3
35–72	.8	3.2	5.9	16.7	18.1	47.5	7.8	16.5	1.5
72–96	3.0	8.6	7.1	13.7	11.6	34.3	21.7	32.0	0
96+	22.3	21.4	8.7	12.5	8.2	17.5	9.4	13.8	0

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, of sample taken from section 28, township 13 north, range 2 east.

[2] Organic matter and mineral matter dissolved by H_2O_2.

PODZOL SOILS

The Podzol soils, developed under the higher rainfall and slightly cooler climate of the eastern part of the county, are illustrated by the light-textured soils of the Cispus and Greenwater series. The Greenwater soils are developed from gray and dark-gray pepper-and-salt sands composed primarily of basic rock materials.

A profile of Greenwater loamy sand about a mile south of Elbe Bridge is as follows:

A_0 1 to 0 inch, medium-acid very dark-brown organic mat of partly decomposed leaves, twigs, moss, and needles.

A_2 to B_{21}. 0 to 11 inches, medium to strongly acid yellowish-brown (10 YR 5/4) and grayish-brown (10 YR 5/2) single-grained nonplastic loamy sand variegated with gray, brown, and yellowish sand and specks of fine pumice; thin ashy-gray layer occurs irregularly just underneath the organic mat.

B_{22}. 11 to 30 inches, medium-acid yellowish-brown and grayish brown loamy sand; small concentrated spots of cemented iron and considerable iron staining on particles; massive structure.

C_1. 30 to 42 inches, yellowish-brown, gray, and pepper-and-salt olive-gray (5 YR 4/2) medium-acid coarse sand; compact but easily broken to a single-grain structure; small spots of cemented iron; sand particles highly stained with iron.

C_2 42 inches +, olive-gray (5 Y 5/2), dark olive-gray, and yellow coarse angular medium-acid sand that holds up well in cuts but can easily be broken down to a single-grain structure.

Cispus pumicy sandy loam, gently undulating, is derived from pumice. It is characterized by an organic mat underlain by a thin ashy-gray layer that grades into discolored pumice and grayish-brown material. This layer is about 8 inches thick and rests on nearly white or very pale-brown pumice that is about 4 feet thick. The underlying material is variable.

PRAIRIE SOILS

The Prairie soils occupy only a small total area in the county. Although they have developed from material similar to that of the surrounding forested soils, they are very different. Persisting in a region and under a climate where timber trees grow to great size, they form small timberless areas or islands in the coniferous forest. They support various grasses, some bracken, and in places scattered oaks or limby firs. Fir trees are slowly encroaching on areas that have been heavily grazed. The Prairie soils are members of the Fitch, Spanaway, Nisqually, Winlock, Doty, and Mossyrock series. The Fitch soil could be classified as Brown Podzolic.

The Fitch, Spanaway, and Nisqually soils have developed from loose and porous gravel and sand on the outwash plain of the last continental glaciation. They are characterized by a 10- to 20-inch layer of moderately acid, nearly black, sooty surface soil over porous subsoil of dominantly acid igneous origin. According to Nikiforoff (*9*) the prairie condition results from the climatic shadow cast by the Olympic Mountains and, in part, from the droughty nature of the soils, which limits the growth of forest trees. He points out, however, that similar associated soils have a heavy forest cover.

The Winlock, Doty, and Mossyrock soils are developed from material similar to those of the Salkum, Onalaska, and Cinebar series, respectively. They are characterized by a dark grayish-brown to nearly black surface soil over a yellowish-brown subsoil. Analyses

of the organic-matter content of four prairie soils and three timbered associates are given in table 12.

TABLE 12.—*Analyses of the organic matter in the surface of prairie soils and some timbered soil associates*

Soils	Carbon	Organic matter	Nitrogen	Carbon-nitrogen ratio
Soils developed under prairie cover of grass and fern:	*Percent*	*Percent*	*Percent*	
Mossyrock silt loam	8.05	13.83	0.626	12.86
Doty silty clay loam	6.26	10.79	.456	13.7
Winlock silty clay loam, gently undulating	4.46	7.68	.276	16.15
Nisqually loamy sand	2.66	4.57	.246	10.80
Soils developed under coniferous cover:				
Winston gravelly loam, gently undulating	6.54	11.23	.332	19.7
Salkum silty clay loam, undulating	3.59	6.17	.145	24.7
Cinebar silt loam, gently rolling	4.48	7.70	.248	18.05
Lynden fine sandy loam [1]	2.13	3.66	.134	15.9

[1] A typical forested soil in western Washington, but not mapped in this county.

The surface layer of the Prairie soils listed in table 12 has a higher average organic-matter content than that of the forest soils—9.22 percent against an average of 7.19 percent. The carbon-nitrogen ratio shows that each Prairie soil has a much narrower ratio than the corresponding forested soil, the average for the Prairie soils being 13.4 against 19.6 for the forested soils. Thus a more desirable type of organic matter has formed under the prairie vegetation, and this fact explains in part the higher inherent fertility of virgin prairie areas when first brought under cultivation.

Mechanical analyses and organic-matter content of Mossyrock silt loam are given in table 13.

TABLE 13.—*Mechanical analyses and organic-matter content of Mossyrock silt loam* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–3	2.9	3.3	3.1	8.2	12.3	53.4	16.8	27.9	13.0
3–14	1.4	2.6	2.8	8.9	13.3	53.5	17.5	28.1	12.3
14–21	.4	2.5	3.1	8.9	15.6	59.5	10.0	21.0	9.4
21–40	.7	2.8	3.2	9.2	20.2	57.2	6.7	16.4	6.6
40–72	.7	3.4	3.8	10.0	15.3	53.4	13.4	22.5	2.5

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering; sample taken in section 14, township 12 north, range 2 east.

[2] Organic matter and mineral matter dissolved by H_2O_2.

INTRAZONAL SOILS

The intrazonal order consists of soils with more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief, parent material, or age over the normal effect of climate and vegetation. These soils may be found associated with two or more of the zonal groups.

The intrazonal soils in Lewis County have developed largely under conditions of excessive moisture caused by a perched or high ground-water table. They occur in depressions and on concave slopes or low-lying areas and are predominantly hydromorphic. Unlike the well-drained brown soils formed under coniferous forests or the nearly black soils formed under grass vegetation, these soils have developed under a dense growth of deciduous trees, brush, and water-tolerant vegetation.

Some of the intrazonal soils are dark-colored; others are light gray. Except for a few areas of organic soils, they characteristically contain some subsoil mottling resulting from the alternating oxidation and reduction process that takes place with fluctuation in the soil-moisture content. The intrazonal soils of Lewis County are placed tentatively in the following great soil groups: (1) Humic Gley, (2) Planosols, (3), Bog, and (4) Half Bog.

HUMIC GLEY SOILS

The Humic Gley soils have many characteristics of the eastern Humic Gley soils but lack the pronounced grey gley layer and have instead a mottled gray, rusty-brown, and orange subsoil and substratum.

This group includes the Baugh, Clackamas, Dryad, Everson, Galvin, and Kosmos soils. The Baugh soil is influenced by a ground-water table and has some characteristics of the poorly drained Alluvial soils. The Clackamas soils have restricted drainage, owing to their heavy texture, and have developed some characteristics of the Prairie soils. The Dryad soils have some features somewhat similar to those of the Planosols. The Galvin soils have many characteristics of the "brown lateritic" soils.

The Kosmos soils are typical of the Humic Gley soil group. A profile of Kosmos clay loam collected in section 27, township 12 north, range 5 east, is described as follows:

A_{11}. 0 to 9 inches, dary-gray (10YR 4/1) granular clay loam, very dark gray (10YR 3/1) and slightly plastic when wet; about 7 percent organic matter; some pumice; pH, about 5.5.

A_{12}. 9 to 19 inches, very similar to layer above except structural units are larger and more dense.

B or G. 19 to 27 inches, gray (10YR 3/1) medium blocky clay loam, which becomes dark gray (10YR 4/1) and moderately plastic when wet; considerable number of ¼-inch light yellowish-brown pumice fragments; medium acid.

Cg. 27 inches +, mottled gray (10YR 5/1) and yellowish-red (7.5YR 5/6) medium blocky strongly plastic silty clay; structural units break into sharp angular fragments; pH, 6.0.

Mechanical analyses and organic-matter content of Kosmos clay loam are given in table 14.

TABLE 14.—*Mechanical analyses and organic-matter content of Kosmos clay loam* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–9	0.7	5.0	5.0	9.8	8.9	36.8	33.8	42.6	7.1
9–19	.7	4.3	4.9	9.6	9.3	37.3	33.8	42.5	6.7
19–27	4.8	7.6	5.6	10.1	7.7	31.8	32.4	40.2	3.1
27+	.4	1.0	1.1	3.9	5.2	46.7	41.7	55.4	1.5

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, of sample taken from section 27, township 12 north, range 5 east.
[2] Organic matter and mineral matter dissolved by H_2O_2.

PLANOSOLS

Some of the soil series in this county classified as Planosols have a dark-colored surface soil; others have a light-gray surface soil. All have a distinct claypan and a gray leached layer ¼ to 1 inch thick above the claypan. They do not have the typical shotlike concretions of the Brown Podzolic soils but, in places, have small dark and generally soft concretions throughout the profile.

The Planosols include the Kopiah and Klaber soils (which also show features characteristic of the Humic Gley soils) and soils of the Lacamas, Meskill, Scamman, and Tower series. Lacamas silt loam, typical of this group, is very similar to the Dayton soils in Oregon. It differs from those soils, however, in having a more plastic substratum and being developed under forest vegetation.

Lacamas silt loam—developed on large nearly level depressions from old mixed materials similar to the parent material of the Salkum soils—has a profile as follows:

A_1. 0 to 12 inches, light-gray (10YR 7/1) silt loam, which is gray (10YR 6/1) when wet; mellow and friable; pH, 4.5.

A_2 12 to 14 inches, white (10 YR 8/1) friable floury silt loam, which is light gray (10YR 7/1) and very slightly plastic when wet; in places mottled with yellow and orange; pH, 4.5.

B_{21}. 14 to 20 inches, abrupt change to a light olive-gray (5Y 6/2) very dense waxy plastic clay; faint columnar structure; tops of columns strongly coated with light ashy-gray (10YR 8/1) material that also coats the surface of the units and occurs in streaks and fingers downward; dense clay restricts water movement; pH, 4.5.

B_{22}. 30 to 32 inches, light olive-gray dense very plastic clay; blocky structure; a few stringers of ashy material penetrate along the structural cleavage planes; pH, 4.5.

C. 32 inches +, light-gray (5Y 7/2) dense sticky clay having no definite structure; less compact than layer above; pH, 5; at 4 or 5 feet grades into highly stained disintegrating gravel of the Salkum parent material.

The Kopiah, Klaber, Meskill, Scamman, and Tower soils all have profiles similar to the one just described, especially in regard to the abrupt claypan subsoil with ashy-gray capping.

Table 15 gives mechanical analyses and organic-matter content for Tower silty clay loam. This soil is very similar to the Lacamas soils, except its dark-gray surface soil (10YR 4/1) becomes very dark gray (10YR 3/1) when wet.

Mechanical analyses of Kopiah silt loam are given in table 16. This soil does not have so dense or plastic a subsoil as the Lacamas soils.

TABLE 15.—*Mechanical analyses and organic-matter content of Tower silty clay loam* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–10	0.1	0.2	0.5	2.3	5.0	57.6	34.3	44.6	6.5
10–12½	.1	.7	1.1	4.2	6.8	68.4	18.7	29.7	.9
12½–18	0	.4	.6	2.4	5.3	54.4	36.9	47.3	.5
18+	.1	.4	.6	3.6	4.7	47.1	43.5	52.6	.3

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, of sample taken in section 14, township 11 north, range 2 west.
[2] Organic matter and mineral matter dissolved by H_2O_2.

TABLE 16.—*Mechanical analyses and organic-matter content of Kopiah silt loam* [1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter [2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–12	0.3	1.0	1.0	4.6	8.0	65.9	19.2	29.4	4.2
12–20	.5	.4	.8	3.8	8.3	60.2	26.0	34.9	.4
20–36	.4	.4	.6	2.4	5.7	35.3	55.2	60.6	.5
36+	1.9	4.3	4.0	9.1	9.4	38.9	32.4	39.3	.2

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering.
[2] Organic matter and mineral matter dissolved by H_2O_2.

BOG AND HALF BOG SOILS

The Bog soils are an intrazonal group of soils that have a mucky or peaty surface soil underlain by peat. They developed under swamp or marsh vegetation, mostly in a humid or subhumid climate. Only a small area of these soils are mapped in Lewis County. They consist of Rifle peat and Carbondale muck.

The Bog soils are derived from organic remains of plants in various stages of decomposition. The kinds of plants and the stage of their decomposition are important in identification and classification. Bog soils are formed in low basins or shallow depressions where standing water or seepy conditions result from a continuously high water table. Generally they have formed from remains of plants in the following stages of ascending succession: (1) Aquatic vegetation in open water forming the sedimentary peat; (2) sedges and reeds in open marshes accumulating sedge peat; and (3) brush, shrubs, trees, and water-tolerant vegetation of swamps and forest forming the woody peat. At latter stages, after the bases become exhausted and the acid condition cannot be tolerated by the other plants, sphagnum, hypnum, and other mosses may follow.

The word "peat" is used to designate organic soils in which the remains may be identified as consisting of partly decomposed fibers of plant materials.

The word "muck" is used for well-decomposed finely divided organic remains usually more or less mixed with mineral soil. The fibers of the organic material are not readily recognizable. The mucks mapped in Lewis County include only woody muck, classified as Carbondale muck.

The only soil series classified as Half Bog in Lewis County is the Snohomish. Snohomish soils consist of dark-colored highly organic mineral underlain by mucks and peats in various stages of decomposition.

AZONAL SOILS

Owing to their youth, the soils of alluvial flood plains have not developed profile characteristics and are classified as azonal. The character of the soils is determined largely by the nature of their parent materials and the manner in which they have been sorted and deposited. Although many of these soils owe their differences to poor drainage, they are derived from relatively recent alluvium and their profile development is immature. Nevertheless, most of them, excepting the Pilchuck and some types of the Newberg and Puyallup series, have color, pH, structural, and textural horizons.

On the basis of drainage the Alluvial soils can be classified in two general groups: (1) Well to moderately well-drained, and (2) poorly drained. The first group includes Chehalis, Newberg, Pilchuck, Puyallup, Siler, and Sultan soils; the second group, Cove, Puget, Reed, Schooley, and Wapato soils. The poorly drained soils have many characteristics in common with the Humic Gley soils.

The Alluvial soils occur in two principal groups according to origin of their parent materials. The Chehalis, Newberg, Wapato, Reed, and Cove soils are derived from mixed basalt, sandstone, and shale materials. The Chehalis soils have a rich-brown or chocolate-brown very granular and friable surface soil and a firm but permeable brown subsoil. Table 17 gives mechanical analyses and organic-matter content for Chehalis silty clay loam.

The Newberg soils are distinguished by their lighter textured surface soil and sandy subsoil and by their more recent position adjacent to stream channels. The Wapato, Reed, and Cove soils are hydromorphic associates of the Chehalis and occur under restricted drainage

TABLE 17.—*Mechanical analyses and organic-matter content of Chehalis silty clay loam*[1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter[2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–15	0.1	0.2	0.3	2.1	5.5	54.3	37.5	53.8	6.1
15–22	.1	.1	.2	.9	2.3	51.2	45.2	63.6	2.9
22–40	0	0	.3	1.4	3.5	49.0	45.8	64.6	1.5
40–72	0	0	.1	.6	1.4	42.7	55.2	73.5	1.4

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering.
[2] Organic matter and mineral matter dissolved by H_2O_2.

TABLE 18.—*Mechanical analyses and organic-matter content of Reed clay*[1]

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Less than 0.005 mm.	Organic matter[2]
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–7	0	0.4	0.2	1.1	1.7	12.6	84.0	89.3	7.4
7–14	0	.2	.3	1.4	2.1	11.4	84.6	89.4	6.1
14–20	0	.1	.2	1.1	1.3	8.5	88.8	92.4	2.3
20–40	0	.1	.2	1.0	2.3	21.6	74.8	79.5	.7
40+	.1	.4	1.4	17.5	10.5	17.6	52.5	56.2	.4

[1] Analyses by Mechanical Analysis Laboratory, Division of Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, of sample taken from section 16, township 14 north, range 2 west.
[2] Organic matter and mineral matter dissolved by H_2O_2.

conditions. They have grayish granular surface soil and mottled gray subsoil. Table 18 gives mechanical analyses and organic-matter content for Reed clay.

The Puyallup, Pilchuck, Sultan, Siler, Puget, and Schooley soils are derived from mixed materials other than of sandstone, shale, and basalt rock origin and commonly contain various quantities of glacial rock flour. The Puyallup soils are moderately well drained to well-drained and have a light brownish-gray friable surface soil over a pale yellowish-brown upper subsoil and a stratified olive-gray pepper-and-salt lower subsoil. The Pilchuck soils are more recent and more sandy. The Siler soils are similar to the Puyallup soils but have a more olive color and a strata of pumice within 10 to 20 inches of the surface. The Sultan soil occurs under slightly restricted drainage; the Puget soil, under the poorly drained conditions associated with the Puyallup soil. The Schooley soils are the poorly drained associates of the Siler soils.

LITERATURE CITED

(1) Baur, K., Huber, G. A., and Wheeting, L. C.
1941. BORON DEFICIENCY OF ALFALFA IN WESTERN WASHINGTON. Wash. Agr. Expt. Sta. Bul. 396, 16 pp., illus.

(2) Bretz, H. J.
1913. GLACIATION OF THE PUGET SOUND REGION. Wash. Geol. Survey Bul. 8, 244 pp., illus.

(3) Byers, H. G., Alexander, L. T., and Holmes, R. S.
1935. THE COMPOSITION AND CONSTITUTION OF THE COLLOIDS OF CERTAIN OF THE GREAT GROUPS OF SOILS. U. S. Dept. Agr. Tech. Bul. 484, 39 pp.

(4) Culver, H. E.
1919. THE COAL FIELDS OF SOUTHWESTERN WASHINGTON. Wash. Geol. Survey Bul. 19, 155 pp., illus.

(5) Dunn, L. E., and Wheeting, L. C.
1941. UTILIZATION OF BARNYARD MANURE FOR WASHINGTON SOILS. Wash. Agr. Expt. Sta. Bul. 395, 19 pp.

(6) Grunder, M. S.
1936. GREEN MANURE OR COVER CROPS IN WESTERN WASHINGTON. Wash. State Col. Ext. Serv. Bul. 223, 10 pp., illus.

(7) Hegnauer, L.
1941. WESTERN WASHINGTON PASTURES. Wash. State Col. Ext. Serv. Bul. 155, 12 pp., illus. (Rev.)

(8) Mangum, A. W., and party.
1913. RECONNAISSANCE SURVEY OF SOUTHWESTERN WASHINGTON. U. S. Dept. Agr. Bur. Soils Field Oper. 1911, 136 pp., illus.

(9) Nikiforoff, C. C.
1937. INVERSION OF THE GREAT SOIL-ZONES IN WESTERN WASHINGTON. The Geographical Review, 27 (2): 200–213, illus.

(10) Reeves, B.
1938. WASHINGTON—ITS PEOPLE, PRODUCTS, AND RESOURCES. Wash. Bur. of Statis. and Immigr. V. 3, 288 pp.

(11) Snyder, J. C.
1938. STRAWBERRY GROWING IN WASHINGTON. Wash. State Col. Ext. Serv. Bul. 246, 15 pp., illus.

(12) ———
1941. FILBERT GROWING IN WASHINGTON. Wash. State Col. Ext. Serv. Bul. 263, 20 pp., illus.

(13) United States Department of Agriculture.
1938. SOILS AND MEN. U. S. Dept. Agr. Yearbook 1938, 1232 pp., illus.

(14) Vincent, C. L.
1936. GROWING PEAS FOR CANNING IN WASHINGTON. Wash. Agr. Expt. Sta. Bul. 150, 28 pp., illus.

(15) Washington State Historical Society.
1940. BUILDING A STATE. Wash. State Hist. Soc., V. 3, 607 pp., illus. Tacoma.

(16) Weaver, C. E.
1916. THE TERTIARY FORMATIONS OF WESTERN WASHINGTON. Wash. Geol. Survey Bul. 13, 327 pp., illus.

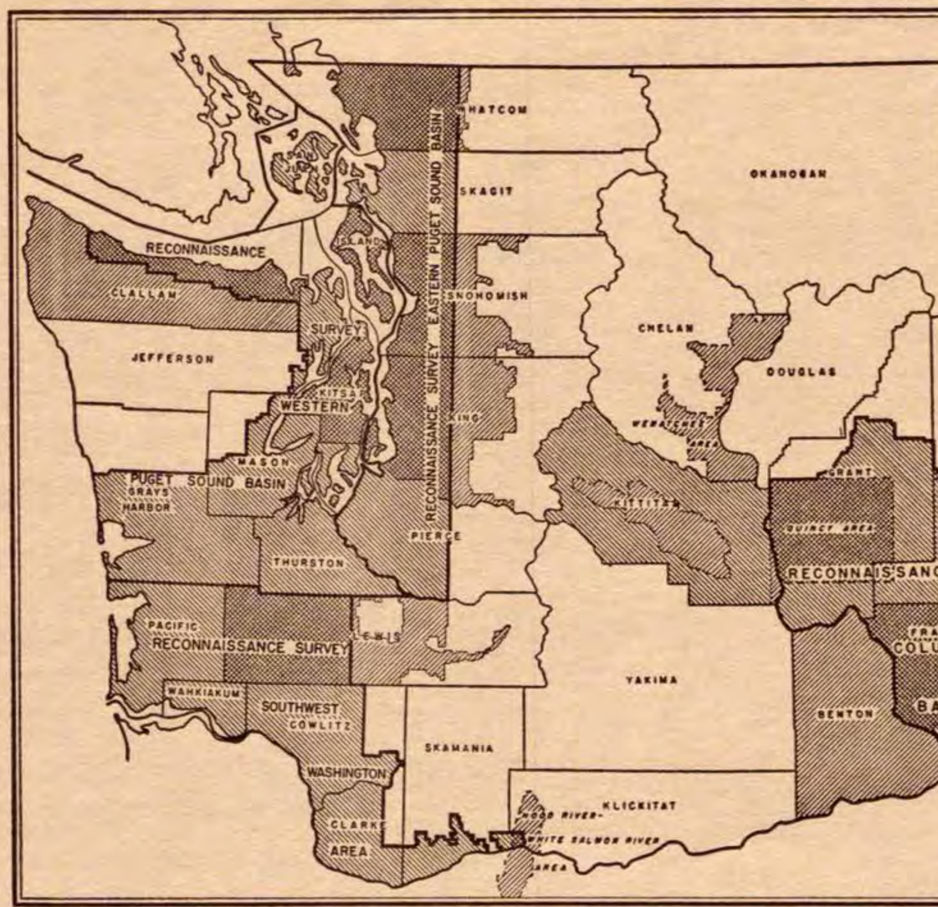
(17) Wheeting, L. C.
1936. SHOT SOILS OF WESTERN WASHINGTON. Soil Sci. 41: 35–45, illus.

(18) ———
1937. CHANGES IN ORGANIC MATTER IN WESTERN WASHINGTON SOILS AS A RESULT OF CROPPING. Soil Sci. 44: 139–149, illus.

(19) ———
1940. COOPERATIVE FIELD EXPERIMENTS WITH COMMERCIAL FERTILIZER MIXTURES. Wash. Agr. Expt. Sta. Bul. 392, 48 pp., illus.

U. S. GOVERNMENT PRINTING OFFICE: 1954

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $2



Areas surveyed in Washington shown by shading. Detailed surveys shown by nort
naissance surveys shown by northwest-southeast hatching; cross hatching indica

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457–3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all of its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex (including gender identity and expression), marital status, familial status, parental status, religion, sexual orientation, political beliefs, genetic information, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write to:

USDA
Assistant Secretary for Civil Rights
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, S.W., Stop 9410
Washington, DC 20250-9410

Or call toll-free at (866) 632-9992 (English) or (800) 877-8339 (TDD) or (866) 377-8642 (English Federal-relay) or (800) 845-6136 (Spanish Federal-relay). USDA is an equal opportunity provider and employer.

U. S. DEPARTMENT OF AGRICULTURE

SOIL MAP

LEWIS COUNTY - WASHINGTON

EASTERN SHEET

WASHINGTON AGRICULTURAL EXPERIMENT STATION

STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

J. Kenneth Ableiter, Chief Soil Correlator.
C. P. Barnes, Chief Analyst, Soil Uses and Productivity.
Inspection and correlation by R. C. Roberts, Principal Soil Correlator, Far Western States.
Soils surveyed 1939-41 by R. H. Fowler, in charge, and A. O. Ness,
Washington Agricultural Experiment Station.

Scale 1:63,360

1 ½ 0 1 2 3 4 Miles

5000 0 5000 10000 15000 Feet

Map compiled by Cartographic Section, Division of Soil Survey, BPISAE,
from plane table traverse, utilizing control secured from U. S. Geological Survey
and Corps of Army Engineer topographic quadrangles.
H. W. Whitlock, Engineer in Charge.
Map drafting by Tennessee Valley Authority, Maps and Surveys Branch.
Polyconic projection. 1927 North American datum.
10 000 foot grid based on Washington (South) rectangular coordinate system

LEWIS COUNTY, WASHINGTON, SOILS: SUMMARY OF IMPORTANT CHARACTERISTICS

Soils	Map symbol	Topographic position	Parent material	Slope	Color of surface soil	Consistence of subsoil[1]	Moisture supplying capacity[2]	Internal drainage[3]	Depth of root penetration and limiting factor[4]	Present use
				Percent						
Baugh pumicy loam	Ba	Terrace depression	Pumice	0–3	Dark brownish gray	Nonplastic	Moderately high (water table).	Slow	Shallow, coarse textured	Forest, water-tolerant pasture.
Carbondale muck	Ca	Depression	Organic woody accumulations.	0–2	Dark grayish brown	Slightly plastic	High (water table)	do	Deep	Pasture, reed canarygrass (wet).
Shallow (over dense clay)	Cb	do	do	0–2	do	Very strongly plastic	Moderately high (water table).	do	Shallow; claypan	Pasture, hay (wet).
Chehalis silt loam	Cc	Alluvial flood plains	Sedimentary and basaltic alluvium.	0–3	Brown	Slightly plastic	Moderate	Moderate	Deep	General farm crops.
Mottled subsoil	Cd	do	do	0–3	do	do	do	do	do	Do.
Chehalis silty clay loam	Ce	do	do	0–3	do	Moderately plastic	do	do	do	Do.
Mottled subsoil	Cf	do	do	0–3	do	do	do	do	do	Do.
Cinebar silt loam: Gently rolling	Cg	Terraces and uplands	Mixed silty pumicy materials (loesslike).	5–15	do	Very slightly plastic	do	do	Moderately deep; low fertility.	Hay, pasture, forest.
Hilly	Ch	do	do	15–30	do	do	Moderately low	do	do	Forest, pasture.
Undulating	Ck	do	do	2–5	do	do	Moderate	do	do	Hay, pasture, forest.
Cispus pumicy sandy loam: Gently undulating	Cl	Terraces	Pumice	2–5	Grayish brown	Nonplastic	Low	Free	Very shallow; coarse textured.	Forest.
Sloping	Cm	do	do	5–15	do	do	do	do	do	Do.
Clackamas silty clay	Cn	do	Mixed gravelly valley filling.	0–3	Very dark grayish brown.	Strongly plastic	High	Slow	Moderately deep; cemented layer.	Pasture, forest.
Clackamas silty clay loam	Co	do	do	0–3	do	Moderately plastic	do	do	do	Pasture, hay, forest.
Cove silty clay	Cp	Alluvial flood plains	Sedimentary and basaltic alluvium.	0–3	Nearly black	Strongly plastic	do	do	Deep	Hay, pasture.
Cove silty clay loam	Cr	do	do	0–3	do	do	do	do	do	Do.
Doty silty clay loam	Da	Terraces	Mixed silty and gravelly valley filling.	2–5	Very dark brown	Slightly plastic	Moderate	Moderate	do	General farm crops.
Dryad silt loam	Db	do	Mixed silty valley filling	2–5	Light brownish gray	Moderately plastic	Moderately high	Moderately slow	Moderately deep; clay	Hay, pasture, forest.
Dryad silty clay loam	Dc	do	do	2–5	Brownish gray	do	do	do	do	Do.
Everson clay loam	Ea	Terrace depressions	Mixed gravelly valley filling.	0–3	do	do	High (water table)	Slow	Moderately shallow; cemented layer.	Pasture, hay, water-tolerant trees.
Fitch gravelly sandy loam, undulating.	Fa	Outwash terraces	Gravelly glacial outwash	2–5	Brown	Nonplastic	Low	Rapid	Shallow; coarse textured	Pasture.
Galvin loam, very gently sloping.	Ga	Alluvial fans	Shale and sandstones	2–5	Light brownish gray	Slightly plastic	Moderately high	Moderately slow	Deep	General farm crops, pasture.
Galvin silt loam, very gently sloping.	Gb	do	do	2–5	Grayish brown	Moderately plastic	do	do	Moderately deep, clay	Do.
Galvin silty clay loam: Gently sloping	Gc	do	do	5–10	do	do	do	do	do	Pasture.
Very gently sloping	Gd	do	do	2–5	do	do	do	do	do	General farm crops, pasture.
Glenoma loam	Ge	Terraces	Mixed silty valley filling	2–5	do	Slightly plastic	Moderate	Moderate	Moderately deep; low fertility.	Hay, pasture.
Glenoma silt loam	Gf	do	do	2–5	do	do	do	do	do	Do.
Grande Ronde silt loam, shot phase.	Gg	do	do	2–5	Brown	do	do	do	do	Hay, pasture, forest.
Grande Ronde silty clay loam, shot phase.	Gh	do	do	2–5	do	do	do	do	do	Do.
Greenwater fine sand	Gk	River terraces	Mixed sandy valley filling and pumice.	1–4	Yellowish brown	Nonplastic	Moderately low	Rapid	Very shallow; coarse textured.	Pasture, forest.
Greenwater loamy sand	Gl	do	do	1–4	do	do	do	do	do	Forest.
Greenwater sandy loam	Gm	do	do	1–4	do	do	do	do	do	Do.
Klaber-Olequa silty clay loams.	Ka	Terrace depressions	Mixed silty and gravelly valley filling.	2–5	Light brownish gray and brown.	Moderately plastic	High (perched water table).	Slow to moderate	Moderately shallow; cemented layer.	Hay, pasture, grain, forest.
Klaber silt loam, gravelly subsoil.	Ke	do	do	0–3	Light brownish gray	Strongly plastic	do	Slow	Shallow; cemented layer	Pasture, water-tolerant trees.
Klaber silty clay loam	Kf	do	do	0–3	Light brownish gray or light olive.	Moderately plastic	do	do	Moderate shallow; claypan.	Hay, pasture, forest, grain.
Gravelly subsoil	Kg	do	do	0–3	Light brownish gray	Strongly plastic	do	do	Shallow; cemented layer	Forest, pasture, hay.
Kopiah-Onalaska silty clay loams.	Kb	Terraces	do	2–5	Light brownish gray and brown.	Moderately plastic	do	Slow to moderate	Moderately deep; cemented.	Do.
Kopiah-Salkum complex, sloping.	Kc	do	do	6–15	do	do	do	do	do	Forest, pasture.
Kopiah silt loam	Kd	Terrace depressions	do	0–3	Light brownish gray	Strongly plastic	do	Slow	Moderately shallow; claypan.	Pasture, water-tolerant trees.
Kosmos clay loam	Kh	do	Mixed silty valley filling	0–3	Dark brownish gray	Moderately plastic	do	Moderately slow	Moderately shallow; clay	Pasture, hay.
Lacamas silt loam	La	Depressions	Mixed silty and gravelly valley filling.	0–3	Light olive gray	Very strongly plastic	do	Slow	Moderately shallow; claypan.	Forest, pasture hay.
Lacamas silty clay loam	Lb	do	do	0–3	do	do	do	do	do	Do.
Lynden fine sandy loam	Lc	Outwash terraces	Sandy glacial outwash	1–4	Light reddish brown	Nonplastic	Low	Rapid	Moderately deep; coarse textured.	Gardens.
Made land	Ma	Variable	Variable	5–45	Variable	Variable	Variable	Variable	Variable	Forest.
Melbourne-Meskill silty clay loams.	Mb	Uplands	Shale and sandstone	10–20	Light brownish gray	Moderately plastic and strongly plastic.	Moderate	Moderate and slow	Moderately deep; rock	Forest, pasture.
Melbourne silty clay, hilly	Mc	do	do	10–20	Dark brown	Moderately plastic	do	Moderate	do	Forest.
Melbourne silty clay loam: Hilly	Md	do	do	15–30	Dark grayish brown	do	do	do	do	Do.
Rolling	Me	do	do	6–15	do	do	do	do	do	Hay, grain, pasture.
Steep and hilly	Mf	do	do	30–45	do	do	do	do	Moderately shallow; rock	Forest.
Meskill-Melbourne silty clay loams.	Mg	do	do	6–15	Light brownish gray	Strongly plastic and moderately plastic.	High (perched water table).	Slow and moderate	Variable	Pasture, forest.
Meskill silt loam, sloping	Mh	do	do	6–15	Light gray or light brownish gray.	Strongly plastic	do	Slow	Moderately shallow; claypan.	Pasture, grass hay.
Meskill silty clay loam: Moderately steep	Mk	do	do	15–25	do	do	do	do	do	Forest, pasture.
Sloping	Ml	do	do	6–15	do	do	do	do	do	Pasture, forest.
Mossyrock silt loam	Mm	Terraces	Mixed silty valley filling	1–4	Very dark brown	Very slightly plastic	Moderate	Moderate	Deep	General farm crops.
Nesika clay loam, seep phase	Na	Alluvial fans	Basaltic materials	2–5	Dark grayish brown	Moderately plastic	High (water table)	do	Moderately deep; coarse textured.	Pasture.
Nesika gravelly loam: Gently sloping	Nb	do	do	5–10	Dark brown	Very slightly plastic	Moderately low	Rapid	Shallow; coarse textured.	Forest, pasture.
Very gently sloping	Nc	do	do	2–5	do	do	do	do	Moderately shallow; coarse textured.	Do.
Nesika loam: Gently sloping	Nd	do	do	5–10	do	Slightly plastic	Moderate	Moderate	do	Pasture, forest.
Very gently sloping	Ne	do	do	2–5	do	do	do	do	Moderately deep; coarse textured.	Hay, pasture, grain.
Nesika soils, undifferentiated	Nf	do	Basaltic materials and pumice.	3–8	Variable	Nonplastic	Low	Rapid	Shallow; coarse textured	Forest.
Newberg fine sandy loam	Ng	Alluvial flood plains	Mixed sedimentary and basaltic materials.	1–4	Light brown	do	Moderate	do	Deep	General farm crops.
Newberg loamy fine sand	Nh	do	do	2–5	do	do	Moderately low	do	Moderately shallow; coarse textured.	Pasture, forest.
Newberg sandy loam	Nk	do	do	2–5	do	do	do	do	Moderately deep; coarse textured.	General farm crops.
Newberg silt loam	Nl	do	do	1–3	Brown	do	Moderate	Moderate to rapid.	Deep	Do.
Nisqually loamy sand	Nm	Outwash terraces	Sandy glacial outwash	2–5	Very dark grayish brown.	do	Low	Rapid	Shallow; coarse textured	Pasture, truck crops.
Olequa silt loam: Gently undulating	Oa	Terraces	Mixed silty valley filling.	2–5	Brown	Slightly plastic	Moderate	Moderate	Deep	General farm crops.
Sloping	Ob	do	do	5–15	do	do	do	do	do	General farm crops, forest.
Olympic silty clay loam: Hilly	Oc	Uplands	Basalt	15–30	Reddish brown	do	do	do	Moderately shallow; rock	Forest.
Rolling	Od	do	do	6–15	do	do	do	do	Moderately deep; rock	General farm crops, forest.
Olympic stony silty clay loam: Hilly	Oe	do	do	15–30	do	do	do	do	Very shallow and stony; rock.	Forest.
Rolling	Of	do	do	6–15	do	do	do	do	Shallow and stony; rock	Do.
Onalaska silt loam	Og	Terraces	Mixed gravelly valley filling.	0–5	Dark brown	do	do	do	Moderately deep; cemented layer.	Hay, grain, pasture, forest.
Onalaska silty clay loam	Oh	do	do	0–5	do	Moderately plastic	do	do	do	Do.
Pilchuck and Puyallup loamy sands.	Pa	Alluvial flood plains	Mixed basaltic material and glacial flow.	1–4	Light gray, gray, dark gray, and light olive gray.	Nonplastic	do	Rapid	Moderately deep; coarse textured.	Pasture, forest.
Pilchuck gravelly sand	Pb	do	do	2–5	do	do	Low	do	Very shallow; coarse textured.	Forest.
Pilchuck loamy sand	Pc	do	do	1–4	do	do	do	do	Moderately shallow; coarse textured.	Pasture, forest.
Over Puyallup fine sandy loam.	Pd	do	do	0–3	do	do	Moderately low	do	Deep	Grass, hay, pasture.
Pilchuck sand	Pe	do	do	2–5	Light gray or light olive gray.	do	Low	do	Shallow; coarse textured	Pasture, forest.
Puget silt loam	Pf	do	do	0–3	Light brownish gray	Slightly plastic	High (water table)	Slow	Deep	Pasture, water-tolerant trees.
Puyallup fine sandy loam	Pg	do	do	0–3	Grayish brown	Nonplastic	Moderate	Moderate	Moderately deep; coarse textured.	General farm crops.
Puyallup loamy fine sand	Ph	do	do	0–5	Light grayish brown	do	do	Rapid	do	Pasture, hay.
Puyallup silt loam	Pk	do	do	0–3	Grayish brown	Very slightly plastic	do	Moderate	Deep	General farm crops.
Reed clay	Ra	do	Mixed sedimentary and basaltic materials.	0–3	Dark brownish gray	Strongly plastic	High	Slow	Moderately deep; claypan.	Pasture, hay, forest.
Reed silty clay loam	Rb	do	do	0–3	do	do	do	do	do	Do.
Riffe loam	Rc	River terraces	Mixed sandy valley filling	2–5	Brown	Very slightly plastic	Moderate	Moderate	Moderately deep; coarse textured.	Forest, hay, grain.
Riffe sandy loam	Rd	do	do	2–5	Dark brown	do	do	Rapid	do	Do.
Rifle peat	Re	Depressions	Organic woody accumulation.	0–2	do	Slightly plastic	High (water table)	Slow	Deep	Hay, grain, pasture.
Pumicy	Rf	do	Organic woody accumulation and pumice.	0–3	do	do	do	do	do	Pasture.
Shallow (over dense clay)	Rg	do	Organic woody accumulation.	0–2	do	do	do	do	Shallow; claypan	Pasture, hay, forest.
Riverwash	Rh	River bottoms	Coarse-textured alluvium	0–5	Variable	Nonplastic	Very low	Rapid	Very shallow; coarse textured.	Forest.
Rough broken land	Rk	Uplands	Variable	20–40	do	Variable	Variable	Moderate	Variable; rock	Do
Olympic soil material	Rl	do	Basalt	20–40	do	do	do	do	do	Do.
Rough mountainous land: Olympic and Cispus soil materials.	Rn	do	Basalt and pumice	30–50	do	do	do	do	do	Do.
Olympic soil material	Rm	do	Basalt	30–50	do	do	do	do	do	Do.
Olympic, Wilkeson, and Cispus soil materials.	Ro	do	Basalt and pumice	30–50	do	do	do	do	do	Do.
Wilkeson soil material	Rp	do	Mixed silty material	30–50	do	do	do	do	do	Do.
Salkum silty clay loam: Deep, nearly level	Sa	Terraces	Weathered mixed gravelly materials.	0–3	Dark brown or brown	Moderately plastic	Moderate	do	Deep	Pasture, general farm crops, forest.
Moderately steep	Sb	do	do	15–30	do	do	do	do	Moderately shallow; cemented layer.	Forest.
Rolling	Sc	do	do	6–15	do	do	do	do	Moderately deep; cemented layer.	Pasture, general farm crops.
Rolling, deep	Sd	do	do	6–15	do	do	do	do	Deep	Do.
Undulating	Se	do	Mixed gravelly valley filling.	3–6	Brown	do	Moderate	do	Moderately deep; cemented layer.	Do.
Scamman-Lacamas complex	Sf	do	Mixed silty and gravelly valley filling.	2–5	Light yellowish brown	Strongly plastic	High (perched water table).	Moderately slow	Moderately shallow; claypan.	Pasture, forest.
Scamman silt loam	Sg	do	do	2–5	do	do	do	do	do	Hay, pasture, grass, forests
Scamman silty clay loam	Sh	do	do	2–5	do	do	do	do	do	Do.
Schooley loam	Sk	Low terraces	Mixed sandy valley filling and pumice.	0–3	Dark brownish gray	Slightly plastic	High (water table)	Rapid	Moderately deep; coarse textured.	Pasture, water-tolerant trees.
Schooley silt loam	Sl	Alluvial flood plains	do	0–3	Light brownish gray	do	do	Slow	do	Hay, pasture, water-tolerant trees.
Siler fine sandy loam	Sm	do	do	2–5	Light grayish brown	Very slightly plastic	Moderate	Moderately slow	Deep	General farm crops.
Siler silt loam	Sn	do	do	2–5	do	do	do	Moderate	do	Do.
Snohomish silt loam, pumicy	So	do	Mixed mineral and organic material and pumice.	0–3	Grayish brown	Slightly plastic	High (water table)	Slow	do	Pasture, hay (wet).
Snohomish silty clay loam	Sp	do	Mixed mineral and organic material.	0–3	do	do	do	do	do	Pasture, water-tolerant general farm crops.
Spanaway gravelly sandy loam.	Sr	Outwash terraces	Gravelly glacial outwash	1–5	Very dark grayish brown.	Nonplastic	Very low	Rapid	Shallow; coarse textured	Pasture.
Sultan silt loam	Ss	Alluvial flood plains	Mixed basaltic materials and glacial flows.	0–3	Grayish brown	Slightly plastic	High	Moderate	Deep	General farm crops.
Tower silty clay loam	Ta	Terrace depressions	Mixed silty and gravelly valley filling.	0–3	Dark brownish gray	Very strongly plastic	High (perched water table).	Slow	Moderately shallow; claypan.	Pasture, hay.
Vader loam, hilly	Va	Uplands	Sandstone	10–20	Brown	Very slightly plastic	Moderately low	Rapid	Moderately shallow; rock	Forest.
Wapato-Chehalis silty clay loams.	Wa	Alluvial flood plains	Mixed sedimentary and basaltic materials.	0–3	Grayish brown and brown.	Moderately plastic	High (water table)	Slow	Deep	Hay and pasture.
Wapato-Galvin complex	Wb	do	do	2–5	do	do	do	do	do	Do.
Wapato silt loam	Wc	do	do	0–3	Grayish brown	do	do	do	do	Do.
Wapato silty clay loam	Wd	do	do	0–3	do	do	do	do	do	Do.
Wilkeson silt loam: Hilly	We	Uplands and terraces	Mixed silty material (loesslike).	15–30	Brown	Slightly plastic	Moderately high	Moderate	Moderately shallow; low fertility.	Forest.
Rolling	Wf	do	do	6–15	do	do	do	do	Moderately deep; low fertility.	Forest, pasture.
Winlock, silt loam, gently undulating.	Wg	Terraces	Mixed gravelly valley filling.	2–5	Dark brown	do	Moderate	do	Moderately deep; cemented layer.	General farm crops.
Winlock silty clay loam: Gently undulating	Wh	do	Weathered mixed gravelly materials.	2–5	do	do	do	do	do	Do.
Level	Wk	do	do	0–2	Dark grayish brown	Moderately plastic	Moderately high	do	Moderately shallow; cemented layer.	Do.
Sloping	Wl	do	do	5–15	Dark brown	do	Moderate	do	Moderately deep; cemented layer.	Do.
Winston gravelly loam, gently undulating.	Wm	River terraces	Mixed gravelly valley filling material.	2–5	Brown	Very slightly plastic	Moderately low	Rapid	Moderately shallow; coarse textured.	Pasture, forest, grain.
Winston gravelly sandy loam: Gently undulating	Wo	do	do	2–5	do	Nonplastic	Low	do	Shallow; coarse textured	Do.
Moderately steep	Wp	do	do	15–30	do	do	do	do	Very shallow; coarse textured.	Forest.
Sloping	Wr	do	do	5–15	do	do	do	do	Shallow; coarse textured	Forest, pasture.
Winston loam, gently undulating.	Wn	do	do	2–5	do	Very slightly plastic	Moderate	do	Moderately shallow; coarse textured.	Pasture, forest, grain.
Winston silt loam, nearly level	Ws	do	do	0–3	do	Slightly plastic	do	Moderate	do	Do.

[1] In general, refers to consistence of subsoil when wet.

[2] Refers to quantity of water held available to plants during the growing season at a depth readily penetrated by roots. In general, soils with moderate supplying capacity have medium-textured subsoil and deep friable profiles; soils with high supplying capacity are those having a high ground water table or perched water table caused by a claypan or hardpan, and in general require artificial drainage for minimum production of cultivated crops· soils with low supplying capacity have coarse-textured subsoils and are droughty.

[3] Refers to downward movement of water in the absence of a high water table.

[4] The depth of root penetration and limiting factor refers to the depth that roots can readily penetrate the soil under adequate drainage. The depths used here are as follows: Very shallow (less than 10 inches); shallow (10 to 20 inches); moderately shallow (20 to 36 inches); moderately deep (36 to 60 inches); deep (more than 60 inches). The terms used for limiting factors and their definitions are: Fertility (too low for root growth); coarse (loose coarse material); cemented (cemented material like hardpan or cemented gravels); claypan (dense plastic clay layer); clay (moderately plastic clays and semicemented material); rock (bedrock).

U. S. GOVERNMENT PRINTING OFFICE: 1954

U.S. DEPARTMENT OF AGRICULTURE

SOIL MAP

LEWIS COUNTY - WASHINGTON

WESTERN SHEET

WASHINGTON AGRICULTURAL EXPERIMENT STATION

STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

J. Kenneth Ableiter, Chief Soil Correlator.
C. P. Barnes, Chief Analyst, Soil Uses and Productivity.
Inspection and correlation by R. C. Roberts, Principal Soil Correlator, Far Western States.
Soils surveyed 1939-41 by R. H. Fowler, in charge, and A. O. Ness,
Washington Agricultural Experiment Station.

Scale 1:63,360

1 ½ 0 1 2 3 4 Miles

5 000 0 5 000 10 000 15 000 Feet

Map compiled by Cartographic Section, Division of Soil Survey, BPISAE,
from plane table traverse, utilizing control secured from U. S. Geological Survey
and Corps of Army Engineer topographic quadrangles.
H. W. Whitlock, Engineer in Charge.
Map drafting by Tennessee Valley Authority, Maps and Surveys Branch.
Polyconic projection. 1927 North American datum.
10 000 foot grid based on Washington (South) rectangular coordinate system.